Journal of Chemical Education

Published by

Division of Chemical Education of The American Chemical Society

Easton, Pa.

Entered as Second-class Matter, January 31, 1924, at the Post Office at Easton, Pa., under the Act of March 3, 1859. Accepted for mailing, at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized January 31, 1924.

Copyright, 1927, by Division of Chemical Education, American Chemical Society

Vol. IV **September, 1927** **No. 9**

CONTENTS

	Page
Frontispiece	1074
Editor's Outlook	1075
A Russian Physical Chemist of the Eighteenth Century. B. N. Menschutkin	1079
Electricity and Matter. Wm. S. Johnson	1088
Progress of Chemistry in the First Quarter of the 20th Century. S. C. Lind	1098
Kunckel and the Early History of Phosphorus. Tenney L. Davis	1105
The Relation of Chemistry to Health and Disease. Wm. McWhorter Loehr	1114
Chemistry as an Instrument of General Education. Dorothy Baker	1120
The Relation of Chemistry to Agriculture. John Livak	1126
The Relation of Chemistry to the Home. Enos Abernathy	1132
The Relation of Chemistry to National Defense. Dudley L. Harley	1138
Chemistry in the Copper Mining Industry. Frank A. Whiteley	1145
A Glance at the Early Organic Chemistry of America. Edgar F. Smith	1150
The Balancing of Oxidation-Reduction Equations. II. E. R. Jette and V. K. LaMer	1158
An Experiment in Predicting Performance in General Chemistry. Maude B. Scofield	1168
A Laboratory Examination in First-Year College Chemistry. John R. Lewis	1176
Industrial Chemistry by the Unit Plant Method. C. L. Mantell and Allen Rogers	1183
Correspondence	1188
Chemical Digest:	
Abstracts	1191

The New England Industrial Situation from the Standpoint of Modern Chemistry; The New Humanism. Preface to Volume IX of Isis; La théories de la composition des sels et la théorie de la combustion d'après Stahl et ses disciples; Vocational Courses and the Junior High School; Adventures in Public Education; Who Should Go to College? The College Student; Charles W. Eliot; A Study of the Relative Value of Three Methods of Teaching High-School Chemistry; The Placement of Teachers a State Function; Possibilities of Objective Techniques in Supervision; Interest and Ability in Educational Guidance; A New and Sensitive Test for Nitrates Applicable in the Presence of Nitrites; Surface Tension of Liquid Metals. Part 2; Science in Japan; Tyndall's Experiments on Magne-Crystallic Action; Toxic Gas and the Boll Weevil; Presentation of the Medal of the American Institute of Chemists; Isotopes of Calcium; A Micro Blood Sugar Method and the Blood Sugars of Insects; Biochemistry; The Meaning of Radioactivity for the Face of the Earth; The Students of Chemistry in the Prussian Technical High Schools and Universities; Individual Instruction in High School; Shooting Stars; Many Students Now Pay Their Way through College; Home Study of High-School Students; State Examinations in High-School Science. A Protest; Principles Underlying the Curriculum; Moral Character the Aim of Education; Henry Paul Talbot; College Teachers; In the Wash; Innovation in Method of Instruction at Harvard; Dyes and Their Application: Recent Technical Progress; Chemical Formulas of Mineral Compounds

Local Activities and Opportunities	1200
Recent Books	1202
A Few Moments with the Business Manager	1207
Magazine Service	1208

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for assistant chemist.

Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than September 27th.

The examination is to fill vacancies in the Departmental Service, Washington, D. C., and in positions requiring similar qualifications for duty in the field. At present there is a vacancy in the Bureau of Mines, Department of Commerce, for duty at Berkeley, Calif., requiring special education or experience in calorimetry and thermodynamics.

The entrance salary in the Departmental Service is $2400 a year. After the probationary period required by the Civil-Service act and rules, advancement in pay will depend upon individual efficiency, increased usefulness, and the occurrence of vacancies in higher positions. For appointment outside of Washington, D. C., the salary will be approximately the same.

Optional subjects are advanced inorganic chemistry, analytical chemistry, organic chemistry, and physical chemistry.

Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience; and a publication or thesis to be filed with the application.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the board of United States civil-service examiners at the post-office or customhouse in any city.

Cathode Rays Help Cure Rickets. Cathode rays from the tube recently invented by Dr. W. D. Coolidge of the General Electric Company's Research Laboratory are like sunlight in their power to give certain substances the quality of preventing rickets. In the current issue of *Science*, Dr. Arthur Knudson, of the Albany Medical College, gives some of the details of his studies. These were made in coöperation with the General Electric scientists at Schenectady, where the laboratory is located.

Persons or animals suffering from rickets, a disease of the bones, can be cured by exposure to ultra-violet rays, either from an artificial source or from sunlight. Dr. Knudson tried exposing rats with rickets to the cathode rays, but with no effect.

However, when he took a chemical substance called cholesterol, which is present in many living tissues, and exposed it to the rays, it was then able to cure the disease when administered. Previously, the cholesterol could be fed to the rats without curing them at all.

Other substances were likewise affected. Brewers' yeast, cornstarch and cottonseed oil, none of which ordinarily is able to cure rickets, were exposed to the rays and then they were found to have the curative power. Yeast exposed to the rays for 30 seconds was found to be ten to twenty times as powerful in its curative effects as cod-liver oil, ordinarily used as a cure.

Similar effects had previously been found on exposing cholesterol to ultra-violet rays. Such exposure gives it the curative power, but, according to Dr. Knudson, much longer exposures are required than with the cathode rays. The cathode rays are quite different from the ultra-violet rays, however. The former are like the rays of light that affect our eyes, except that they vibrate too rapidly to be seen. The cathode rays consist of streams of rapidly moving electrons, the "atoms" of electricity of which matter is believed to consist.—*Science Service*

Michájlo Vasílievič Lomonósov
1711–1765

EDITOR'S OUTLOOK

A Russian Chemist

PROFESSOR B. N. Menschutkin, who presents, on the following pages, a most delightful sketch of the earliest practical physical chemist, is at present attached to the Polytechnic Institute in Leningrad where he is engaged in teaching chemistry—indeed, is occupied in this way for many hours each day. His father was Professor N. Menschutkin of the University of St. Petersburg, and the author of an excellent work on chemical analysis, which in its German dress may have been used by many who read these lines. The son, our contributor, has published a splendid biography of him, as he has of Mendeléeff and other Russian chemical worthies. In addition to his activity in research work, he is intensely interested in the history of chemistry—especially chemistry in Russia; indeed, he prepared a volume on the latter subject, the manuscript of which, however, was unfortunately lost through a combination of circumstances. But he hopes that he may yet succeed in his plans. From him we learn that the distinguished Mendeléeff had performed a similar task but his labors, too, are not available.

It may be added that Professor Menschutkin is at present occupied in preparing the fourteenth edition of his father's analytical volume for the press, which is, of course, the property of the government, and six years ago he wrote the life of Nicolaus Zinin—who first showed how the nitro-group might be changed to the amido-group, when by action of ammonium sulfide on nitrobenzene he obtained aniline. It was this reaction which A. W. Hofmann said "should be recorded in letters of gold."

We trust that Professor Menschutkin may ere long give to the world a history of our science in Russia. It would be welcomed by chemists everywhere.

The Prize Essays

THE prize-winning essays in the high-school prize essay contest for 1926–27 are presented in this issue. It seems to us that the present high-school essays are, on the whole, the best that we have had the privilege of publishing thus far. We believe that, taken as a group, they represent a standard of high-school work higher than the standard of college work represented by this year's college essays.[1] We venture that opinion purely in praise of the one group and with no intention to dispraise the other. However, at the opening of a new school year we should no doubt turn our faces forward rather than backward and proceed to the laying and execution of plans for the coming contest.

[1] See THIS JOURNAL, 4, 711–48 (June, 1927).

The recommendation that teachers begin early in the year to stimulate interest in the essay contests and to prescribe helpful reading for their students is not based solely upon the general principle that an early start in anything is advisable. Many students enter upon first courses in chemistry with some knowledge of the contributions which the science has made toward human welfare and with a curiosity to further explore the romantic aspects of the subject. Too often the formal and rather dry subject-matter which they immediately encounter is a rude shock to their preconceived notions and tends to blight rather than to nourish the budding interest which they bring to the class-room. One teacher of long and successful experience recently said that he has found the prize essay work an excellent means of bridging this gap between romance and hard actuality.

Not every teacher cares to make the essay contest a prescribed part of the class work. Some of them feel that projects of this nature should constitute extra-credit work for ambitious and exceptionally able students. We believe, however, that wherever the teacher feels so inclined he may very properly assign the preparation of essays as a broadening feature of the course. It is beyond the limits of possibility for any text-book to include any considerable quantity of the sort of material which is contained in the popular volumes recommended and issued by the Chemical Foundation and the teacher himself has all too little lecture time to devote to such topics. The contest provides an incentive to additional reading and the preparation of an essay constitutes an excellent report upon the intelligence and industry employed in that reading. After the reports have been made the more promising essayists may still be encouraged to employ their greater talents in the revision and amplification of their papers for submission to the prize essay committee.

The Chemical Industries and Their Exposition

THE period since the entrance of the United States into the World War has been one of almost revolutionary industrial development. Yet even in an era of unprecedented expansion and advancement the group of industries which may be roughly classified as chemical is preëminent for the strides it has made. No other group has increased so rapidly in numbers of participants or in volume of production. No other group has devised so many new processes for producing old commodities, so many new commodities to compete with or replace old ones, nor so many hitherto unknown articles of commerce. Moreover this development has spread out and affected almost every phase of industrial activity. It would be difficult, indeed, to discover a major

industry which the chemist and the chemical engineer have not invaded and benefited.

Hence, when a chemists' exposition is arranged a cross section of the country's industrial system is laid open to public view. The Eleventh Exposition of Chemical Industries, which will occupy the Grand Central Palace in New York City from September 26th to October 1st, will include some three hundred and fifty exhibitors. Raw materials, products, apparatus, machinery, and even processes will be displayed and explained in detail. Naturally the greater part of the exposition is of domestic origin but foreign manufacturers will also be represented.

Many special sections have been instituted among the exhibits in this exposition. The section of chemical and chemical product exhibits is three times as extensive as it was five years ago, the machinery exhibits have increased in number and variety, the instrument exhibits have made remarkable strides in their accuracy, application, and usefulness, and likewise in number. Besides these usual exhibits there are of particular interest the sections given over to laboratory supplies and equipment; containers, packaging, labeling, and shipping; plastic compositions; and transportation and material-handling exhibits.

One of the many interesting features of the exposition will be exhibits of stainless steel and iron in the alloy section. These exhibits will contain the latest developments in this branch of the alloys and the leaders will be the Central Alloy Steel Company, Vanadium Corporation of America, and the International Nickel Company. The appearance of fabricated stainless materials dates back only as far as 1912. The Krupps exhibited at the Gothenberg Exposition that year certain stainless articles of commerce manufactured from their highly alloyed nickel chrome steels. It has been only very recently that stainless steel has come to be far more prominent than in any other period in its history. However, constant research is rapidly overcoming the various obstacles in this field and the industrial importance of this alloy is evidenced by the long list of patents in this country of the smaller malleable varieties rather than the steels. Industrial importance in rust-resisting sheets cannot be too strongly stressed because of the protection afforded by such alloys.

Among the exhibits of the United States Government will be two of the chief departments of the National service. Secretary Hoover's Department of Commerce will be represented by the Bureaus of Census, Mines, Standards, Foreign and Domestic Commerce, and the Committee of Wood Utilization. The Department of Agriculture will be represented by several bureaus and laboratories, including the Bureaus of Chemistry, Dairy Industry, Soils, Agricultural Economics, and others.

There will be numerous educational exhibits; one of these will be of

outstanding importance to the industries and arts using benzol. That is the exhibit of the National Safety Council which will present in completed form the recently concluded and exhaustive study of the toxicity of this solvent when used in products designed for manufacturing and domestic use.

The educational programs of the exposition present many aspects; there will be the usual programs of motion pictures, the meetings of societies and the special series of lectures and addresses constituting the Students' Course which has become so notable and well known an institution within the greater institution. Students will come from many colleges, universities, and institutions, both in this country and abroad, to attend the course and receive intensified instruction from specialists, which will supplement and extend their college curriculum in such a manner as is impossible elsewhere.

The Committee and the management of the exposition are preparing a course of lectures by speakers of prominence to give students of chemistry and chemical engineering a perspective of the industry as a whole, to show those who have had only theoretical courses how fundamental or unit processes are carried out on a large scale; and to give students having some training in the field of industrial and chemical engineering the opportunity of hearing special subjects presented to them by experts in their respective fields.

This course will be open to students who are endorsed by their college professors or who are able to show credentials that they are studying chemistry or chemical engineering in some institution; to those who have completed their course of study; to those who wish to refresh their minds upon technical details; and to the teaching staffs of schools and colleges. Registration will begin Monday noon, September 26th, at the exposition. Class work begins Monday afternoon, at 3:00, and the entire group of students will meet for one hour during the afternoon for a lecture of general interest to all. At other times, the classes will be divided into two sections. Section One will consist of all students of chemistry who have not had the opportunity of learning how unit processes are carried out, these students being either those who have taken courses only in theoretical chemistry or those who have not yet reached courses of applied chemistry or chemical engineering. Section Two will be comprised of advanced students in chemical engineering and those who have had sufficient training or experience to understand how chemical equipment is made and works. The full student program is published on pp. 1184–87 of this issue.

A RUSSIAN PHYSICAL CHEMIST OF THE EIGHTEENTH CENTURY

B. N. MENSCHUTKIN, POLYTECHNIC INSTITUTE, LENINGRAD, U. S. S. R.

Science began to be cultivated in Russia in the eighteenth century under Peter the Great, who established the Academy of Sciences and the first university in 1725 in his new capital, St. Petersburg (founded in 1703). The first men of science in these institutions were foreigners who, by and by, began to be replaced by Russians. Of these, during the eighteenth century, one figure stands out preëminently—that of the first Russian professor of chemistry at the Academy of Sciences—Michájlo Vasílievič Lomonósov.[1] A man of genius, a philosopher of many parts, he devoted his life to the pursuit of science—of chemistry, physics, mineralogy, geology, geography, astronomy, history, philology; to arts and technology and to the dissemination of knowledge in Russia. Everywhere his scientific work was of importance, but scarcely understood by his little-educated contemporaries, who held Lomonósov in great esteem, not on account of his scientific genius, but as a poet and creator of the Russian literary and scientific language. Only after 1901, when I commenced to investigate his scientific work, to study his printed memoirs and his many manuscript notes, preserved in the archives of the Academy of Sciences, did his scientific achievements in chemistry and physics become generally known through my publications. I will give here a very short account of Lomonósov and of his chemical and physical work bearing on the history of physics and chemistry.

M. V. Lomonósov was born in 1711 in the village Denísovka, opposite the town Cholmógory on the Northern Dviná, some seventy kilometers from Archángelsk, at that time the chief Russian maritime port. Here foreign ships during the brief warm season discharged their goods, which in winter, when the snow made excellent roads, were conveyed to Moscow and other trading centers by peasants living along the Dviná, by the so-called "pomóry," *i. e.*, men of the sea, who during the summer gain their living by fishing and trading. Lomonósov's father was a wealthy but illiterate pomór, possessing several big sloops. Intending to hand over the business to his son, he taught him all its details and took him on all his trips. Constant intercourse with seafaring people, with foreigners resident in the Dutch, English, and German factories at Archángelsk, with the custom-house employees and other officials made the young Lomonósov eager for an education beyond that which could be obtained at home.

[1] In spelling Russian names I use the rules laid down by the Academy of Sciences: *ch* is pronounced as *h* in "have," *j* as *y* in "say," *c* as *ch* in "chair," *y* as in Polish—there is no English equivalent for it; *e* is pronounced as *e* in "bed," *a* as *a* in "bad," *i* as *i* in "big," *o* as *o* in "not."

Accordingly he left his native village in December, 1730, and after a journey of several weeks with one of the transports came to Moscow, where, representing himself to be a nobleman, he was permitted to enter the Theological Academy. (Peasants, according to the law of the time, could not attend.) In spite of the most abject poverty (he received only 3 kopeks ($1^1/_2$ cents) daily) his progress there was very rapid. He was the first in everything. This stood him in good stead, as, being one of the best Latin scholars, he was sent in 1735 to St. Petersburg and entered the University as a student. There his marvelous aptitude and his intense desire for knowledge singled him out from among his fellow-students and, the Academy happening to be in need of a metallurgical chemist, Lomonósov was selected as candidate for this post and together with two other students was sent to Germany to study chemistry and metallurgy. For three years (1736–1739) he attended the University of Marburg, where, having quickly mastered the German language, he received under the famous philosopher, Baron Christian Wolff, a thorough grounding in the theoretical sciences—philosophy, mathematics, physics, chemistry, mechanics—and also in French, drawing, etc. Hereafter he went for a time to Freiberg (Saxony), studying metallurgy and mining under one of the foremost metallurgists of the time—A. Henckel. He visited also many towns and mines and became acquainted with the leading German men of science. After many adventures Lomonósov returned to St. Petersburg in the autumn of 1741, when he was made adjunct of the Academy and in 1745 ordinary academician and professor of chemistry. Hereafter he occupied important posts in the Academy and the University and gained immense popularity as a poet. Many honors and decorations fell to his lot. Tall in stature, possessing great bodily strength and a tremendous voice, he was of a domineering disposition, which made him many enemies in after life. His health began to give way in 1762 under the influence of the then common vice of drink, and he died from influenza in St. Petersburg on April 4, 1765.

The physico-chemical work of M. V. Lomonósov can be referred to two periods: during the years 1741–1749 he occupied himself almost exclusively with theoretical physics; after 1749, with chemical investigations. Lomonósov's physical papers form a complete natural philosophy, which, as he wrote to his friend, the well-known mathematician, Leonhard Euler, he was afraid to give to the world at large "lest it should be considered a fruit of unripe mentality." But he published some of his theories and several unfinished dissertations were found among his manuscripts.

The whole physical philosophy of Lomonósov rests on the basis of his molecular theory, almost identical with that used now in chemistry; he never published it, but wrote much about it during the years 1741–1743. He distinguishes molecules and atoms: molecules are extremely

minute corpuscles, parts of bodies having all the properties of the latter and obeying all the laws of mechanics; the molecules are composed of atoms (he calls them elements) of different chemical principles. In all his writings Lomonósov stresses the necessity of investigating the properties of molecules, as in them lies the key of the properties of matter. "Their cognizance must be made through chemistry. . . It is true that up to now the sharp eye of the investigator could not penetrate thus far into the innermost of bodies. But if this secret is one day discovered there is no doubt that chemistry will be the first to do it, will be the first to lift the veil from this innermost sanctuary of nature." (*Discussion on the Utility of Chemistry*, 1751.) "Just as bodies cannot be formed but from impalpable molecules, so without their investigation it is impossible to establish the doctrine of intrinsic physics. . . In complete darkness work physicists and chemists without knowing the innermost impalpable structure of molecules." (*Dissertation on the Solidity and Fluidity of Bodies*, 1760.) In his *Elements of Mathematical Chemistry* (1741) Lomonósov says that different molecules must result from the same number of the same atoms, if these be differently combined—there must be formed bodies possessing different properties, although having the same composition. Thus the existence of what were afterwards (in 1829, by J. J. Berzelius) called isomers was theoretically deduced. As is well known the first actual cases of isomers were discovered in 1824 (fulminate and cyanate of silver, cyanate of ammonia and urea).

The first application of this molecular theory was made in the Latin dissertation, *Reflections on the Cause of Heat and Cold* (written in 1744, printed in 1747), where Lomonósov shows that "heat is nothing but the inner motion of matter," and as all matter is formed of molecules, heat is a motion of molecules. Their motion can be of three kinds—progressive, oscillating, and rotary; experiment makes it evident that only rotary motion can be considered as producing heat in solid bodies. We cannot imagine a limit to the velocity of motion, consequently there can be no limit as to higher temperatures; but we can easily conceive a complete absence of motion of the corpuscles, and that will represent the greatest possible cold, which, as shown by observation, does not exist on this earth. Lomonósov rejects all notions of caloric, igneous matter or heat substance, which were accepted by almost all his contemporaries and scientists up to the middle of last century! Heat transmission between bodies is explained by the transmission of motion from the molecules of the warm body to the molecules of the cold one.

The next paper, also in Latin, *An Attempt to Formulate a Theory of the Elastic Force of Air* (written in 1745, published in 1748), contains the first complete kinetic theory of the gaseous state. Lomonósov deduces his theory from an assumption made by Daniel Bernoulli in 1738, at the

time a member of the Russian Academy of Sciences, as to the nature of air; this assumption was as follows: "Let us take a cylindrical vessel fitted with a movable lid, on which a weight, R, is placed. The space under the lid contains small corpuscles moving with an enormous velocity. Impinging upon the lid and upholding it by their blows, they form an elastic fluid, expanding if the weight R is reduced or removed, and contracting if this weight is increased." (Danielis Bernoulli, *Hydrodynamica*, Section X, ¶2, 1738.)

Lomonósov regards the molecules of air as being very hard, not subject to any physical change, spheric with small asperities on the surface. Suitable experiments are described to show that the elasticity of air is caused by direct interaction between the molecules. "Individual molecules of air during impalpable intervals of time collide with others in chaotic interaction: while some of them are in contact, others rebound one from the other and collide again with the nearest others, rebound again and thus tend to disperse in all directions, continually mutually repelled by such very frequent reciprocal blows." As elasticity of air increases with rise of temperature and decreases with its fall, Lomonósov concluded that, heat being produced by a rotary motion of molecules, the faster the rotation the more violent will be the reciprocal repulsion of the molecules and the greater the elasticity of heated air. It is well known that only after Clausius and Krönig had again proposed it after Waterstone in the sixties of the last century, did the kinetic theory find acceptance by physicists—more than a hundred years after Lomonósov.

Very interesting is the *Supplement to the Reflections on the Elastic Force of Air*, published by Lomonósov in 1749. Here he considers the case of air under very great pressure and shows that under the conditions, as the molecules possess a finite diameter, the collisions between them must take place proportionately more often than if they are more widely spaced as in air under small pressure. Therefore under high pressures "the relation between the elasticities must differ from the relation of densities." This conclusion was arrived at *one hundred fifteen years* after Lomonósov, in 1864, by the French physicist, A. Dupré, and later, in 1873, by van der Waals in his well-known book on the continuity of gaseous and liquid states.

Of the other parts of Lomonósov's natural philosophy I will only mention a *Discourse on the Propagation of Light* (1756), where he declares himself against the emission theory of light, and for the wave theory, bringing forward many experiments indicating the non-existence of a light-substance.

Electricity occupied much of his time, and he wrote several papers on it and on the northern lights, the electrical nature of which he recognized and the altitude of which he determined at about 140 kilometers —a surprisingly accurate figure as shown by the recent measurements

of Vegard and others. In one of his dissertations he shows that atmospheric electricity, identical with that obtained from electrical machines, is generated by friction of air molecules in ascending air currents, which last owe their existence to the fact that air warmed by the sun's rays near the earth's surface is lighter than the upper cold air (1752).

As I have mentioned, the second period of Lomonósov's scientific work, after 1749, is chiefly devoted to chemistry. It was during this year that he was able to build a chemical laboratory—the first in Russia for scientific investigations and the first in the world where university students were regularly taught practical chemistry. It was but a modest affair, measuring about 15 meters in length and 9 in breadth, built of brick for the sum of $650. The first work accomplished in it was the preparation of colored glasses to be used for mosaic pictures; afterward the production of these glasses was removed to special glass-works conducted by Lomonósov. The mosaic pictures were intended for the decoration of a colossal monument to Peter the Great, but the expense was too great and out of eight projected pictures only one was finished by Lomonósov—the battle of Poltava, at the present time in the Academy of Sciences in Leningrad. This picture is 7 meters long and 5 meters high; the original picture was even larger and produces a fine effect, the colors of the glasses being very vivid.

In 1751 Lomonósov began to hold in his chemical laboratory a course of lectures on "physical chemistry" to students of the University. I have found some chapters of them among his manuscripts, under the title, *Course of the True Physical Chemistry* (in Latin, 1752). He defines the new science thus: "Physical Chemistry is a science which must explain by means of physical laws and experiments the cause of changes produced by chemical operations in composite bodies. It can be called chemical philosophy, but has nothing in common with the mystical philosophy where not only are no explanations given, but the operations themselves are enshrouded in secret. We have called this work Physical Chemistry because we have decided to include in it only what conduces to a scientific explanation of the composition of substances. . . The science of Chemistry deals with the properties and changes of bodies." The first chapter, whose beginning I have given, is entitled, "On Physical Chemistry and Its Object" and shows the necessity of studying the properties of molecules (of which all bodies are formed) and of the smallest ultimate particles, which cannot be divided chemically (atoms). Then follow chapters on molecular properties of substances; on means of effecting chemical change; on chemical operations; on composite bodies; on chemical laboratories; on expounding chemistry by means of physics.

These lectures show that Lomonósov was a true physical chemist. He was the first to designate chemistry a *science*—in the middle of the

eighteenth century it was an *art*, the art of decomposing compound bodies into their composite parts and of forming them again from the composite parts (definition of G. E. Stahl). He was a precursor of A. Lavoisier in the introduction of *quantitative methods* of investigation and he was the first to give the conception of the *chemical individual*, of a chemically pure substance, and of the means of ascertaining this individuality—constancy of properties (1745). The views of Lomonósov on the necessity of practising quantitative chemical work are contained in the dissertation of one of his pupils, B. Kleméntiev: "I think every scientific worker knows the almost infinite number of experiments made in chemistry; but he is well aware that almost all authors make no mention of such important and absolutely needful points as measure and weight. . . Without knowing the measure and weight we cannot reproduce without fail a given experiment, accomplished by some earlier worker. . . He who intends to make physico-chemical experiments must therefore always make use of the instruments mentioned—weight and measure."

Like every modern professor Lomonósov recognized that chemistry cannot be taught without practical work in the laboratory; he instituted the very first known laboratory exercises in physical chemistry, consisting of experiments performed by students under his supervision. The programs of this experimental work were discovered by me among his manuscripts, and are amazing, containing, as they do, practically all that was introduced some 130 years after Lomonósov into a physico-chemical practical course by another gifted man of Russian extraction—Wilhelm Ostwald, who is generally held to be the founder of physical chemistry. They include the investigation of properties of chemical individuals, but chiefly of their mixtures; aqueous and other solutions.

Lomonósov began the inquiry into the nature of solutions some years before he lectured on physical chemistry, namely, in 1745, when he published a Latin dissertation, *On the Action of Chemical Solvents in General.* He exposes here his theoretical views on the mechanism of the dissolution process and, by means of some experiments, demonstrates the difference between dissolution accompanied by evolution of heat—as of a metal in an acid—and that unaccompanied by chemical change, absorbing heat, as of a salt in water. Both these cases he designated by different terms, just as A. Lavoisier—who is generally credited with first making this distinction—did 44 years after Lomonósov ("dissolution" of a metal in acid, "solution" of a salt in water).

The physico-chemical investigation of aqueous solutions of salts, Lomonósov proposed to make under the following headings: (*a*) solubility at different temperatures; (*b*) density of saturated solutions at different temperatures; (*c*) increase of volume during dissolution; (*d*) lowering of temperature in the process of dissolution; (*e*) expansion of solution from

0° to 100°; (*f*) ebullition temperature of solutions; (*g*) heat capacity of solutions; (*h*) dissolution of salts in saturated solutions of other salts; (*i*) congelation of solutions; (*j*) refraction of light in solutions as compared with that in water; (*k*) rise of solutions in capillary tubes; (*l*) microscopical observations of solutions; (*m*) action of electrical force on solutions; (*n*) color of electrical sparks produced in solutions; (*o*) crystallization of solutions and investigation of crystals obtained; (*p*) deliquescence of salts. It is obvious that such a program could be used in a present-day laboratory of physical chemistry.

We know little about the actual realization of this gigantic program. There were, of course, immense difficulties in the way, as the technical means of the time were absolutely undeveloped. Lomonósov had to invent all the methods and the apparatus to be used in these investigations; he designed many of them and made their specifications to be executed in the academical workshops; but for the most part these apparatus were not made—many are the reclamations addressed by Lomonósov to the Academy in the hope of hastening their construction. From Lomonósov's yearly reports we know that physico-chemical work was carried on for some four years; but no laboratory journals, mentioned in these reports, have been found in the archives of the Academy. It is needless to point out that to date Lomonósov's program is not yet fully realized; even at present many investigators work out points of it without in the least suspecting that they are but following the lead of the first physical chemist.

The constant use of weight and measure in his experiments enabled Lomonósov to accomplish important work; it showed him also the errors of the phlogistic doctrine, which was indeed incompatible with his views on the nature of heat. Living in an age when every chemist was a firm believer in phlogiston and expressing himself in terms of it, Lomonósov could not publish his opinions on the non-existence of phlogiston without bringing sufficient experimental evidence; but he spoke freely on this matter in his letters to Leonhard Euler. He commenced the investigation of the phenomena of calcination of metals in 1756; the results, which he obtained, are most noteworthy and are contained in the following report to the Academy: "I made experiments in hermetically sealed glass vessels in order to investigate if the weight of metals augments under the influence of pure heat. These experiments demonstrated that the opinion of the famous Robert Boyle is erroneous, as without giving access to the exterior air the weight of the calcined metal does not change."

The "opinion of Robert Boyle," refuted by Lomonósov, was expressed by the former in 1673 in his Latin essay, *Discovered Penetrability of Glass by Ponderous Parts of Flame*. R. Boyle heated in hermetically sealed

retorts some lead; after it was calcined the retort was opened, air entered into it with sybilation and the weight of the retort with the lead was found to have increased; hence he concluded that the matter of flame penetrates glass and combines with the metal. Lomonósov showed that actually no increase in weight takes place after the calcination of metal. Further, from the fact that after the experiment the retort contained always less air than before it, it follows that the calcination of metals consists in their combining with air—that is the explanation of this reaction given by Lomonósov in a letter to L. Euler. It is a matter of universal knowledge that R. Boyle's experiment was repeated 17 years after Lomonósov by A. Lavoisier who, naturally, knew nothing about his predecessor, with the same results as those obtained by Lomonósov. This experiment was the starting point whence A. Lavoisier deduced the composition of air and gave the true explanation of the phenomena of calcination and of combustion.

Lomonósov's experiments of 1756 had also another important result. As early as 1748 he wrote in a letter to Leonhard Euler: "All changes occurring in nature proceed so that if something is deducted from one body, the identical quantity is added to another. Thus the quantity of matter added to a given body is just the quantity taken from another . . . This universal natural law extends also to the laws of motion, for a body driving by its force another body loses just as much force as is gained by the other, receiving its motion from the first." The truth of Lomonósov's universal law was, as regards force, demonstrated in 1738 by Daniel Bernoulli; in 1756 Lomonósov showed it to be valid for chemical change—the reaction metal + air = calcined metal was unaccompanied by change of weight. This is the first experimental demonstration of the law of conservation of weight during chemical change, usually ascribed to A. Lavoisier. Having thus experimentally demonstrated the soundness of his law, Lomonósov published it in 1760 in his Russian *Dissertation on the Solidity and Fluidity of Bodies*, wherein are described the properties of solid (frozen) mercury—the formation of which was noticed for the first time by the academician, I. A. Braun, on December 14, 1759, and investigated by Braun and Lomonósov on Christmas day of the same year, when the intense frost in St. Petersburg (—41°C.) enabled them to prepare a sufficient quantity of solid mercury.

In concluding this brief account of the scientific work of Lomonósov in chemistry and physics I can but repeat the words of P. I. Walden (1921): "Involuntarily a comparison between the first Russian chemist, Lomonósov, and the greatest Russian chemist, D. I. Mendeléeff, presents itself. The first can be called the Mendeléeff of the eighteenth century. Both showed a striking similarity of character and genius. Both were physical chemists, giving their chief attention to the question of solutions.

Both were philosophers, expounding their science from an elevated point of view; but both were practical men and patriots, striving with all their might to apply the science to practical purposes, for the good of their fatherland. Both were masters of word and style, who endowed the Russian scientific language with new expressions and terms. By their work both were titans, by the power of their scientific ideas—men seeing clearly the future of science far ahead of their times."

Scientist Measures Heat Given Off by Heart Beat. A quite normally beating heart, like an automatically equipped storage battery, "discharges" and "recharges" within the period of each beat. From his researches on the hearts of turtles and king crabs, at the Johns Hopkins University, Dr. Charles D. Snyder and his associates have found that even a single beat of the heart will produce heat in proportion to the energy expended.

"This explains at last," Dr. Snyder declared, "the wonder of the heart's great regularity, its constant vitality and the age-long mystery of its indefatigability."

In their experiments every precaution was taken to exclude heat from outside sources. The hearts of turtles and king crabs were used because they will keep beating a long time after the animal itself has been killed. A small thermos jar was placed inside a larger one and in the cap of the smaller jar were fixed hard rubber posts to which the muscles were attached. Through the cap were perforations for the wires connecting the thermopile with the galvanometer for recording heat and for a thread connecting the muscle with a lever outside that recorded the tension. The desired temperature in the inner jar, usually 1 to 3 degrees Centigrade, was maintained with ice. The sensitive thermopile, or heat detector, was placed in close contact with the surface of the muscles, and both heat and tension were finally recorded on a moving photographic film.

It was found that the heart of the king crab produced on the average 71 millionths of a calorie per centimeter of length for each gram of tension exerted and that the ratio of heat produced to the tension exerted per gram of weight of muscle was fairly constant throughout the series of experiments.—*Science Service*

Finds Dried Milk Best of Irradiated Foods. Dried milk that has been treated with ultra-violet light is the most practical of the irradiated foods that have been used to prevent rickets in babies, in the opinion of Dr. Alfred F. Hess, well-known authority on rickets.

"It is the unanimous opinion that dried milk treated in this way prevents or cures infantile rickets and tetany," declared Dr. Hess in a recent report to the American Medical Association.

"The specific activity of the milk is maintained for a period of at least six weeks," added the specialist.

Dried brain, which contains an exceptionally large amount of the parent substance of the rickets-preventing vitamin, has also been found to be a successful antirachitic after irradiation, Dr. Hess stated.

Ergosterol, the contaminating factor in cholesterol that is actually activated by the ultra-violet rays, is the most potent antirachitic substance that has been found yet. As small amounts as 0.002 of a milligram daily will cure rats of rickets, according to data from Dr. Hess's experiments.

Strangely enough, both Dr. Hess and other investigators have found that irradiation lessens rather than increases the potency of cod-liver oil, the best known remedy for rickets in current use.—*Science Service*

ELECTRICITY AND MATTER

WILLIAM S. JOHNSON, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

A few years ago our conceptions of the structure of matter were comparatively simple. All substances were made up of molecules, which, in turn, were built of atoms; the ultimate subdivision of all materials. The periodic table contained eighty odd elements—with room for a few undiscovered ones. Each of these elements contained but one kind of atoms; extremely minute, indivisible, impenetrable, unchangeable spheres; and the atoms of one element were entirely different from those of any other.

Some of those philosophically inclined wondered why in a well-ordered universe there should have to be many elemental units of matter. Prout and others tried to discover a law that would show that all the atomic weights were simple multiples of some one number, but the fractional atomic weights proved too great a difficulty. Further trouble arose from the fact that in spite of many forms of evidence, there was no *positive* proof of the existence of atoms. This condition led Ostwald to suggest that the atomic theory be abandoned and that chemistry be based entirely on thermodynamic laws.

Then Sir J. J. Thompson discovered the electron; the unit charge of negative electricity—a bit of energy capable of a free existence. Shortly after, the Curies discovered radium, and real trouble began. The physicists became the ones to play with atoms and they have turned the simple old theory out of the house and installed a far more complicated one. We still can calculate how much sodium will react with a given weight of water as though the atoms were as Dalton regarded them; and Avogadro's molecules still do their work. But we have an entirely new point of view and, happily, *definite* proof that atoms really exist. To be sure the newer theories are far from complete; many details being uncertain, but we can be sure of the main feature, that all atoms and, therefore, all molecules are special manifestations of electricity.

Atomic Structure

The atoms are not indivisible and immutable, but can be broken down. Moreover, they are not hard, impenetrable spheres, but are of various shapes, and possess a highly open structure. All of the atoms are systems of negative electric charges—the electrons—arranged in definite orbits about a positive electric charge—the nucleus.

The atomic diameter of hydrogen, for example, is about 10^{-8} cm.—one hundred millionth of a centimeter—an inconceivably small value, yet the nucleus and the electron occupy a very small fraction of the total atomic volume. The electron diameter is roughly one hundred thou-

sandth that of the atom, while the hydrogen nucleus is a couple of thousand times smaller than the electron. The remainder of the space is apparently a perfect vacuum.

It is with the nucleus that most of the mass of the atom is associated, and its mass and charge are different in each element. Around the nucleus, revolving in definite levels, or orbits, are the electrons; the number of electrons being that required to neutralize the positive charge of the nucleus. The electrons in the outer levels of the atoms are the ones that take part in chemical action and, therefore, determine the characteristic properties of the element.

Hydrogen, the lightest element, consists of a unit of positive charge as the nucleus, and a single electron revolving about it. Some idea of the relative positions of these two particles may be obtained in this way. Imagine the earth as the nucleus, and the moon as the electron, forgetting the disparity in masses. Then to compare with the distance between nucleus and electron in the hydrogen atom, the moon should be about three thousand times farther away from the earth—*i. e.*, 750,000,000 miles instead of 250,000.

The next element, helium—of atomic weight four—has a nucleus with a double positive charge. It is not merely two positive charges bound together, but is a queer complex of four hydrogen nuclei and two electrons crowded together in an extremely small space. Two electrons revolving about the nucleus complete the atom.

We could go through the whole list of atoms in this way; each succeeding atom being formed by the addition of positive charges to the nucleus and the equivalent number of electrons in orbits about it. The heaviest atom, that of uranium, has a nucleus containing 238 positive charges, and 146 negative charges. The 92 electrons required to balance the excess positive charge of the nucleus are arranged in various orbits about the center of the atom.

This theory implies that there should be no fractional atomic weights, and, in fact, there are none—excepting hydrogen. Those elements whose listed atomic weights are fractional are actually mixtures of two or more kinds of atoms, identical in all their properties except those of weight. They are called isotopes and are inseparable by any chemical methods. Thus, chlorine, whose weight is given as 35.46, is a mixture of two isotopes weighing 35 and 37.

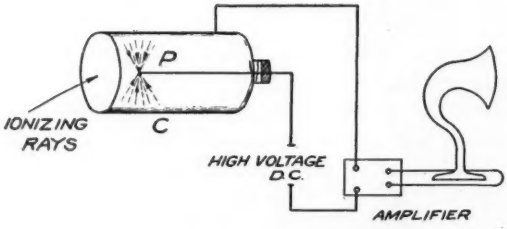
Decay of Elements

For some unknown reason, uranium and thorium (weight 232) are highly unstable and the nuclei break down. The decay is spontaneous, and is unaffected by heat or cold or any other means at our disposal. The decomposition products are unstable, too; so we have a series of

unstable atoms from the radio-active parent ending in a stable atom—an isotope of lead.

There are three types of rays evolved during these processes; α-rays, β-rays, and γ-rays. The α-rays are doubly charged helium atoms (that is, helium atoms from which the two orbital electrons have been removed) which are ejected with great velocity and possess tremendous kinetic energies. The β-rays are electrons. The velocity of the ejected electrons is sometimes enormous—velocities up to 98% that of light being observed, but their mass is so small the kinetic energies do not reach a large value. The γ-rays are electro-magnetic impulses (light waves)

GEIGER APPARATUS FOR DETECTING EMISSION OF IONIZING RAYS



WHEN IONIZING RAYS ENTER CHAMBER C, THE CONDUCTIVITY OF THE SPACE BETWEEN THE WALL AND THE FINE POINT P IS INCREASED ENORMOUSLY AND THE CURRENT PRODUCED IS AMPLIFIED SUFFICIENTLY TO OPERATE A "LOUD SPEAKER."

FIG. 1.—HOOK-UP FOR GEIGER APPARATUS, FOR DETECTING EMISSION OF IONIZING RAYS

of extremely short wave-length, much shorter than X-rays. The three types of radiation are not emitted by the decomposition of a single kind of atom. For example, Uranium 1 (the parent atom) and Radium A give out only α-particles; Uranium X_1 and Radium B only β-particles; and so on.

Practically all the elements not included in the radio-active series of uranium and thorium are stable. It is extremely difficult to break up the nuclei. It is possible, however, to remove electrons from the outer orbits, leaving a positively charged residue or ion. This is in many cases easily accomplished, it being necessary only to give the electron enough energy to escape from the nuclear attraction.

By holding a piece of metallic uranium near the aluminum screen of the apparatus shown in Fig. 1, there is produced an irregular series of sharp "clicks." A doubly charged helium atom ejected from the uranium passes through the window and ionizes the air inside. That is, an α-particle knocks an electron out of a lot of air molecules and leaves them positively charged. A single α-particle produces about 100,000 of these ions, which causes a momentary rush of current that produces the sound in the horn.

Unless the uranium is held very close to the window the number of "clicks" suggests that the decay is rather slow, but, as a matter of fact, a single gram of uranium in equilibrium with its decomposition products emits 5000 α-particles each second. The emission, in time as well as space, follows the laws of chance; so a very small fraction of the α-particles enter the window. Further a good deal of the radiation is absorbed in the metal itself.

In spite of the fact that five thousand atoms break down each second, a piece of uranium will be but half gone in 5,000,000,000 years. That is, in five thousand million years half of it will have lost twelve or thirteen per cent of its weight and left some metallic lead. This lead is an isotope of ordinary lead and differs from the latter only in that its atomic weight is 206, whereas ordinary lead weighs a fraction over 207.

Thorium, the other radio-active parent, goes through a series of decompositions similar to that of uranium and likewise ends with lead. This lead, however, has an atomic weight of 208.

Ions in the Air

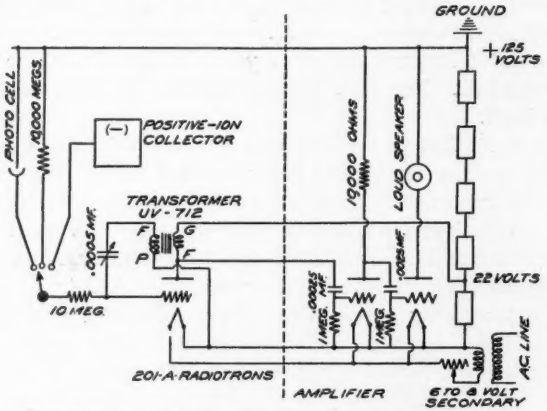
We ordinarily think of air as an insulator, but actually it is not a very good one. Air condensers are used in our radio sets, and the plates are apparently well insulated because the radio works. Sometimes they don't, but usually that is not the fault of the air in the condensers. Nevertheless, air is a conductor, although, to be sure, a very poor one. It must, therefore, contain ions—positive and negative. Under ordinary conditions the air contains about one thousand ions per cubic centimeter, which is an extremely small fraction of the number of molecules present —about one ion to 10^{16} molecules. The ions are formed in several ways: by radio-active decomposition, X-rays, penetrating radiation—the so-called Millikan rays—photo-electric action, and flames. As a result of this conductivity the electro-static charge on a body left in the air gradually leaks away.

The presence of these air ions can be shown by the apparatus shown in Fig. 2. A copper screen is connected to the grid of a pliotron and charged negatively to prevent plate current. The "hook-up" of the apparatus is such that it is very sensitive to decrease in grid potential

and will detect currents of a few thousandths of a microampere. There is usually enough leakage of electricity in the apparatus to cause a steady "tick-tick" in the loud speaker. The sensitivity can be varied by means of a condenser, and should be set so that the leakage will not interfere with the phenomena to be shown.

If an amber rod is rubbed with felt, and thereby given a positive charge, and then pushed toward the screen, some positive ions should be repelled to the latter and be detected by the increasing rapidity of "ticking." (Fig. 3.)

The same effect is given by a negatively charged rod, but in this case



THOMPSON CURRENT INDICATOR HOOK-UP

(This cut reproduced by courtesy of *Industrial and Engineering Chemistry*)

FIG. 2.—THOMPSON CURRENT INDICATOR HOOK-UP FOR DETECTING PRESENCE OF IONS IN AIR

the effect is produced when the rod is drawn away from the screen. The positive ions are collected from the opposite side of the screen.

It was previously mentioned that ionization of the air was produced by flames. This can be shown by blowing a Bunsen flame toward the screen. The roar in the loud speaker indicates the presence of many ions.

A coil of wire, when heated to incandescence, emits electrons with enough velocity to ionize the air; so by blowing the air above it toward the screen, the loud speaker broadcasts the fact.

X-rays produce a large number of ions in the air, and the effect can be shown easily by running an X-ray tube near the screen.

Photo-Electric Effect

By means of another apparatus (Fig. 4) the production of electrons by the action of light—the photo-electric effect can be shown. A clean

metallic surface exposed to ultra-violet light emits electrons, and with some metals, as potassium, the effect may be obtained with visible light. Part of the light energy is absorbed by the electrons, giving some of them a velocity great enough to escape from the atoms.

A portion of the inside of the cell is coated with potassium and held at a negative potential to repel any electrons emitted. In the center of the cell (Fig. 5) is a positively charged electrode to collect the particles. The circuit is devised so that the miniature street lamps are "out" when a

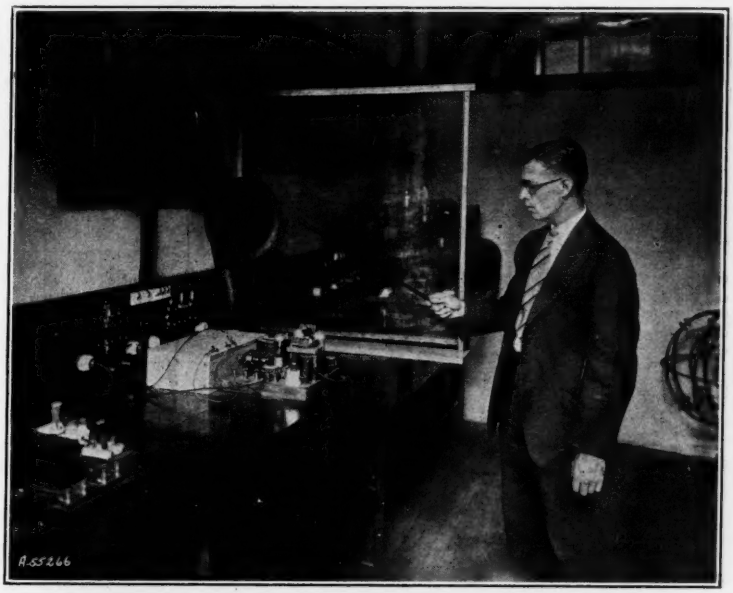


FIG. 3.—BRINGING A CHARGED AMBER ROD NEAR THE SCREEN CAUSES A RAPID "TICKING" IN THE LOUD SPEAKER

current, *i. e.*, a stream of electrons, is flowing through the bulb, and that is possible only when light shines on the potassium. When the bulb is shaded from the light, the emission of electrons stops, and the street lamps are lighted.

Leakage through High Resistance

The current in a metallic conductor is only a stream of electrons through the metal. In insulators there may be an electron current, or even a movement of ions, as in electrolysis. There are no perfect insulators; the best we have being extremely poor conductors.

If in the apparatus shown in Fig. 2, a paper on which is a long ink

mark is connected in place of the screen, the current through the high resistance can be shown. A grounded wire is held by the rubber insulation and the line touched by the other hand. A note is heard that

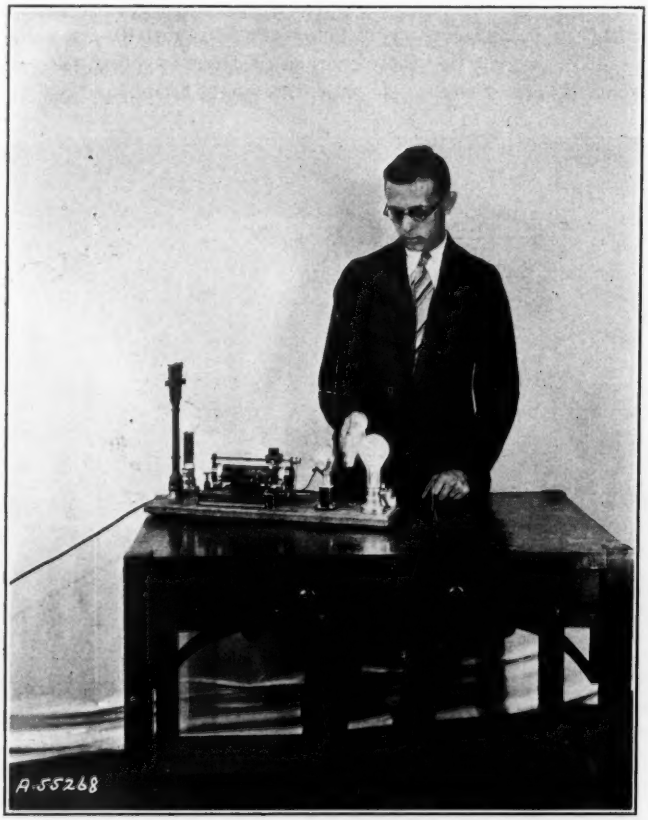


FIG. 4.—PLACING THE HAND BETWEEN THE INCANDESCENT LAMP BULB AND THE PHOTOELECTRIC CELL STOPS THE EMISSION OF ELECTRONS BY THE CELL AND CAUSES THE MINIATURE STREET LAMPS AT THE LEFT TO BE LIGHTED

can be changed by touching different parts of the line. The apparatus is sensitive enough to indicate the current leaking from earth, through the rubber insulation of the wire, the body, and the ink mark to the grid. When a bare, grounded wire is used the frequency of discharge, or the pitch, goes up greatly.

Glass Leakage

Glass is generally regarded as a good insulator; except at high temperatures, where it is a fair conductor. With this same apparatus, however, we can indicate the currents that go through the cold bulb of an electric light. The hot filament of an incandescent lamp emits electrons which give the inside of the bulb a negative charge. If a lighted lamp be touched in place of the grounded wire, the rate of discharge goes up because of the current leaking through the body and the glass bulb from earth. In this case actual electrolysis takes place, and if the bulb be kept grounded for sufficient time a layer of sodium will appear inside the bulb.

High Frequency Effect

The production of electric energy in space can be shown by the high

FIG. 5.—THE PHOTOELECTRIC CELL OR "ELECTRIC EYE"

frequency generator. It is really a small broadcasting station. The circuit is arranged to cause the electron current to oscillate rapidly, so that the electric fields are reversed several million times a second, and thereby produce in the space around the coil, or antenna, an exceedingly high voltage—the induced voltage being proportional to the rate of cutting of the lines of force.

Currents will be induced in a conductor placed near the coil. Thus, any glass tubes containing gases at low pressure glow when placed near the coil—the high voltage causing ionization of the gas.

The field is more intense inside the coil, and by putting in a piece of metal it can be quickly heated to brightness. A common application of the high-frequency furnace is in the bake-out of vacuum tubes during exhaust. The metal parts can be heated to a very high temperature without the necessity of using lead wires for the current.

Barkhausen Effect

There is some peculiarity in the structure of iron, nickel, and cobalt—not yet made clear—that makes them very susceptible to a magnetic

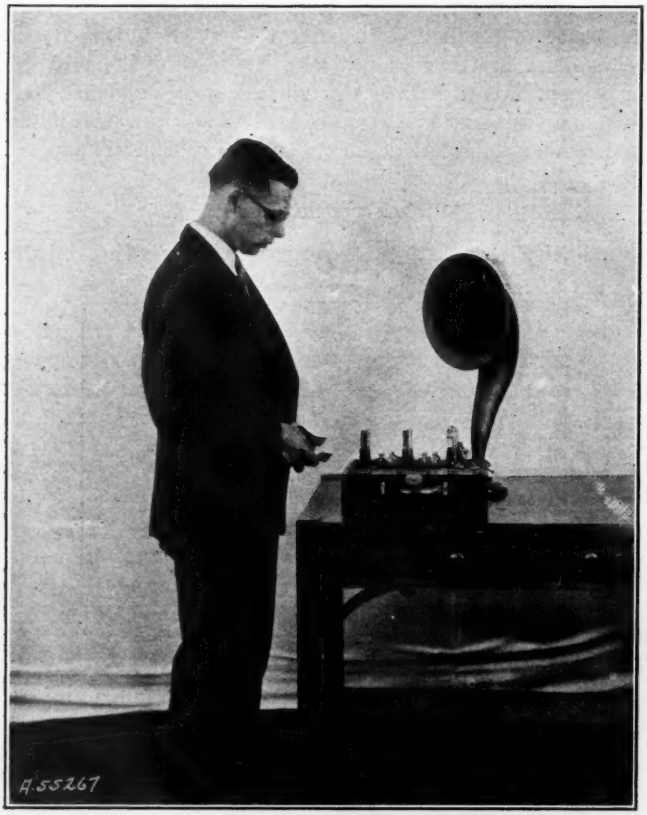


FIG. 6.—LISTENING TO MAGNETISM WITH THE BARKHAUSEN APPARATUS. WHEN THE MAGNET IS BROUGHT NEAR THE PIECE OF SOFT IRON WITHIN TWO COILS OF FINE WIRE, A "SWISH" IS HEARD IN THE LOUD SPEAKER

field. A bar of iron is often pictured as composed of many small magnets so oriented that their north and south poles neutralize one another. A magnetic field is supposed to swing them into line—their north and south poles pointing in opposite directions. It would seem from this picture of the process that magnetization is a continuous change. All the little

magnets move around together more and more as the field strength increases. If one moves, all of them move.

That there is some such twisting or reversal of poles on the magnetic units is made evident by the apparatus shown in Fig. 6. It indicates, however, that the metal does not become magnetized continuously, but by small jumps.

The apparatus consists of two hollow coils of fine wire in series, connected to the grid of a pliotron charged to a negative potential of 1.5 volts. There are a couple of tubes to amplify the current to the loud speaker.

A piece of soft iron, bent in the form of a U can be placed in the center of the coils. Then as the magnet is brought up to the coils, a "swish" is heard in the loud speaker. It is heard again as the magnet is drawn back, or when the poles of the magnet are reversed. The sound is actually a series of single "clicks" following one another in quick succession (as can be shown by means of an oscillograph), and due to rapid variations of the electro-motive force in the coils.

The phenomenon is explained in this way. The iron is not magnetized as a whole, but by small sections. These magnetic units, under the influence of an external field, swing around or suffer a reversal of polarity, and in so doing induce electro-motive forces in the coils. The magnetrons are not affected simultaneously, but what determines the order of response or whether the magnetization occurs in a single step or in several is not known. It is known, however, that the individual magnets are not the atoms, nor are they single crystals.

Ancient Bacteria Founded Modern Iron and Steel Trade. The vast iron mines of Minnesota, of Alsace, of Silesia, and the roaring furnaces of Pittsburgh, of Sheffield, of Essen, all owe their existence to the activities of humble bacteria that swarmed in unimaginable billions in the swamps and pools of long past ages. This vision was conjured up by the somewhat technical paper read before the First International Congress of Plant Sciences in Washington by Dr. Rudolph Lieske of the great German agricultural and forestry experiment station near Berlin.

According to Dr. Lieske, iron is an essential of life to the bacteria that cover the surfaces of wayside pools with rusty films. "Have you had your iron today?" is neither a jest nor an advertisement to these humble creatures. They get the life energy that keeps them going by changing one kind of iron rust into another. And the slow accumulation of their iron-loaded bodies, piling up through multitudinous leisurely millenia, filled the hollow places of the earth with what we now call iron ore.—*Science Service*

Science alone can give us a true conception of ourselves and our relation to the mysteries of existence. Only the sincere man of science—and by this title we do not mean the mere calculator of distances, or analyzer of compounds, or labeler of species; but him who through lower truths seeks higher and eventually the highest—only the genuine man of science, we say, can truly know how utterly beyond not only human knowledge but human conception is the universal power of which nature, and life, and thought are manifestations.—HERBERT SPENCER

PROGRESS OF CHEMISTRY IN THE FIRST QUARTER OF THE 20TH CENTURY*

S. C. LIND, UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINNESOTA

The modern science of chemistry began with the discovery of oxygen almost simultaneously with our Declaration of Independence. It has, therefore, just completed a century and a half of achievement. The progress during the entire period has been stupendous, but at no time has the rate exceeded that attained in the twenty-five years just closed.

The results obtained by the chemist in dealing with the material world may be divided into two general classes, the reproduction of processes and of materials which occur in nature and the production of those which do not. In the production of new substances the organic chemist has exceeded all others. In the past fifty years he had added some 200,000 new chemical substances to the comparatively small number previously known. It is, therefore, surprising that all of the organic compounds are composed of and may be reduced to about a half-dozen elemental substances out of the ninety which compose all matter as we know it today.

On attempting to analyze further these 90 elements we arrive at a particle which the Greek philosophers called the *atom*. To them it was but an *idea*. Their logic told them that ultimately indivisible particles must exist. They felt no necessity to prove or to disprove their theory.

Chemists of the 18th and 19th centuries accepted the Greek atom and built the structure of chemistry about it. On the one hand, the law of definite combining weights in small integral numbers gave indirect support to the theory of atoms, while the kinetic theory of gases enabled the prediction of the number, size, and motion of atoms and molecules, though there was no direct proof of their reality.

At the beginning of the 20th century, we conceived of atoms as small, inelastic, homogeneous spheres, of which there was one and only one kind for each elemental species. For the changes that these atoms were known to undergo there was no adequate physical or chemical basis. They were supposed to be joined together in compounds by means of intangible bonds or valences.

For more than a hundred years, though a mass of evidence had accumulated indicative that such a simple conception of atoms was inadequate, conservatism lay in the way of accepting more radical assumptions. Prout's hypothesis that all the elements were built of the lightest one, hydrogen, had been repeatedly revived and rejected. The Mendeléeff system itself suggested a synthetic structure with periodically recurring

* An address delivered at the dedication of the new Chemistry Building at the University of Colorado, February 19, 1927.

characteristics. The multiplicity of the spectral phenomena plainly pointed to a complex, not to a simple atomic structure. But on the other side stood the law of the conservation of the elements as inferred from the failure of transmutation, and an entire lack of any experimental evidence as to structure or further sub-division of the atom.

In four successive years just preceding 1900, four discoveries were made, than which there has been none greater in the realm of chemistry and physics. In this short time the foundations of the future atomic structure were laid and all of the phenomena which have swept away the firmest tenets of a century were observed. Science suddenly attuned itself to receive the messages which the atoms had been broadcasting since the dawn of time. Their interpretation is the physics and chemistry of the present and apparently will be the chief problem before us for the balance of the century.

In 1895 Röntgen announced the discovery of the rays which bear his name (also called X-rays). In 1896 Becquerel discovered other types of rays accompanying the phenomena of radio-activity. In 1897 Thomson identified the electron as an atom of negative electricity with a mass only 1/1800 that of the hydrogen atom, previously the lightest particle of matter known. And in 1898 the Curies announced the isolation and identification of radium.

Provided with this background, chemistry entered the 20th Century and, hand in hand with physics, has developed the subject of atomic structure with amazing acumen and rapidity. These discoveries have not only furnished links in the chain of evidence, but each has been fitted into every other one with admirable exactness.

In 1903 Rutherford and Soddy announced the law of atomic evolution in explanation of the phenomena of radio-activity. This marked the beginning of the orderly treatment of the new discoveries.

Since all kinds of elements are found to contain electrons, all identical in their properties, evidently the electron must form one of the common constituents of all atoms. Since electrons are electrically negative while atoms are normally neutral, there must also be a balancing positive constituent. Positive electricity not associated with material atoms has not been discovered, and we assume, therefore, that the atom of positive electricity is the proton or nucleus of the hydrogen atom.

Using alpha rays from radium as projectiles, Rutherford, by observing their passage through matter, has proved that the atoms are largely vacant space—that most of the mass is concentrated in a minute core or nucleus with diameter less than 1/10,000 that of the entire atom. The rest of the space is empty except for the small number of electrons necessary to neutralize the positive charge of the material nucleus. The work of Moseley on the characteristic frequency of the X-rays from

different kinds of atoms gives us the total net positive charge of the nucleus, or the atomic number. When we arrange the atoms in the order of the Moseley atomic numbers, we get essentially the same arrangement as that of the periodic system, thus giving it new significance and also reconciling some of its discrepancies in a striking way.

Rutherford showed that when a high-speed alpha particle strikes the nucleus of an atom a proton or swift hydrogen nucleus is ejected.

Thus the atom has been dissected, revealing a structure which theoretically can be built up wholly from two things—protons and electrons. The simplest atom, that of hydrogen, has a nucleus consisting of a single proton and one electron supposed to revolve about it in circular and elliptical orbits. From the work of Bohr all of these spectral lines of hydrogen of the three series of Lyman, Balmer, and Paschen can be exactly interpreted in terms of the energy emitted by the electron in falling from one of the higher orbits back to a lower one.

The next heavier atom, helium, has atomic mass of four, therefore four protons in the nucleus. But since it has atomic number of only two—the net charge on the nucleus is two instead of four, or the helium nucleus must be composed of four protons and two nuclear electrons; two outer electrons maintain electrical neutrality. This suggests that it is impossible to make two or more protons cohere to form a nucleus without some binding nuclear electrons, the relative number of which becomes greater the greater the atomic number.

We may thus proceed hypothetically to build up all of the atoms. With the completion of each successive layer of electrons, their forces balance so exactly that there is no tendency for gain or loss of further electrons. This atom is self-contained and has no chemical affinity. A new layer must then be begun, each layer corresponding to a horizontal row of the Periodic System, and each addition of a new electron and proton to the next higher element.

When we reach the elements of high atomic mass, above about 210 or atomic number of about 76, a region is attained where the nuclei become unstable and occasionally eject either one of the electrons as a beta-ray or one helium nucleus as an alpha-ray. Starting from the heaviest known atom, uranium, or from the next heaviest, thorium, we may follow these successive changes down through the periodic system in two series of radio-elements. Each atom changes to the next by the emission of a particle which controls the nature of the resulting atom; for example, since each atom of uranium emits one alpha-particle, the offspring must have a nucleus of atomic number smaller by two units, and hence two electrons are also lost from the extra-nuclear ones. It has been found that the number of the outermost electrons corresponds to the valence of the elements. The two electrons lost are from the valence group,

those farthest from the center of attraction and hence the ones most weakly bound. The element, therefore, which loses an alpha particle also loses two valence electrons and, hence, the product has a position two places to the left of its parent in the periodic table. Loss of a beta particle causes the opposite changes—increase of atomic number by one unit, gain of one valence electron, and hence a shift of the product one place to the right in the Periodic System. By this same displacement law, the radio-active changes may be traced down to the lower inactive members such as lead.

As a result of the displacement process two or more different radio-active elements often fall into the same position in the Periodic System. To such elements Soddy gave the name "isotopes." Since they have the same number of outer or valence electrons, the similarity of their chemical behavior is so great that it is impossible to separate a mixture of isotopes by any chemical means. Although the atomic number of a group of isotopes is the same, it is an algebraic sum which may be made up in several different ways by adding protons and electrons to give the same nuclear charge but having different nuclear mass.

In the ordinary elements not undergoing atomic change, one had no means of knowing whether isotopes existed, although such a possibility was suspected in some cases from the fractional atomic weights. If the element or a compound of it can be obtained in the gaseous state so as to be ionized by removal of one of its outer electrons the ratio of mass to charge can be determined. In this way Aston has shown that in fact many of the common elements, also light ones, are mixtures of two or more isotopes and the apparently fractional atomic masses are due to a mixture of two or more whole-number atomic masses.

There is no reason to foresee that the isotopes of a given element should always be mixed in the same proportion. Yet since such mixture is not separable by any process known in nature, it is significant to find that the atomic weight and hence the isotopic mixture is identical—not only for elements from various localities of the earth's surface but also for such elements as reach the earth in meteorites.

Some apology may be thought necessary for having confined this account of progress to the elemental substances. From the utilitarian standpoint alone, an element is not necessarily more important than any one of its many compounds. Lime, for example, was used centuries before either of its two elements was known. But certainly from the scientific standpoint a special importance must be accorded the elements and particularly just now, when so much new information has been gained concerning them, which is certain to have the most profound influence on the future of chemical development. Great progress has been made since 1900 in all branches of chemistry, especially in catalysis, in photo-

chemistry, in colloid chemistry, in thermodynamics and in chemical kinetics; but none of these could have made the advances attained without employing the newer concepts of the atom.

To review briefly the results of the four discoveries mentioned at the outset: Protons and electrons are the building stones of the atoms. While the periodic system clearly indicates a synthetic structure of all of the atoms, we know of no place in the universe, according to present speculations, where such a process of building larger from smaller atoms seems to be going on. On the other hand the heaviest atoms are unstable and are spontaneously disintegrating to a certain degree which does not appear to extend far into the lower elements. The radio-active changes are step-wise, each step being accompanied by the ejection from the atom of a single alpha or of a single beta particle, the former being a helium nucleus, the latter a high-speed electron. Either of these in emerging from the atom may set up short wave-length vibrations, or gamma-rays. X-rays may also be set up by external bombardment with electrons in the form of cathode rays, which is the usual way of obtaining X-rays.

The radio-active processes are not only taking place on the earth, but there are good reasons to believe they contribute a large part of the energy radiated by hot stars. It has been suggested by chemists and astronomers that even heavier radio-active elements exist in the interior of the sun which were not represented when the earth was separated from its outer portion.

In our consideration of the atom we must be struck by the fact that when the astronomer directs his telescope into the heavens he finds a system of central bodies, suns, surrounded, in our solar system at least, by satellites moving in elliptical orbits. In the vast spaces of the universe these solar systems seem to move at random (like the kinetic motion of gas molecules) with gigantic free paths and collision frequencies that must be counted in milleniums of light-years.

If instead of looking outward into the universe we look inward into the atom we again have the same picture as if we had but reversed the ends of the telescope thus passing from the infinite to the infinitesimal —again satellites moving in orbits and relatively vast empty spaces traversed only by radiation.

Jeans has recently expressed the idea that the chief function of the universe is to transform matter into radiation which travels on for eons through space, very rarely encountering a body which can absorb any of this vast emission. Life he refers to as "a disease which affects matter in its old age" or a kind of bacterial infection of some of the ashes on the dump heap of the universe. Man is then either but the highest form of this disease called life, or else he is the supreme

central figure and ultimate object of this inconceivably lavish expenditure of energy.

So far as we can know, I think, the correct conception must be the latter. Whatever the business of the universe and man's relation to it, man's business evidently is to inhabit this little planet, and the chemist's is to find out as much as he can about the materials composing it and the rest of the universe and to put this knowledge to use in bettering our material condition and in extending our intellectual and spiritual horizons. The chemist has contributed his full share to the knowledge of the material world and will continue to do so. We stand now on the threshold of a new era of advance. Surely no more fitting time could be chosen to erect a new edifice dedicated to this great objective—the science of chemistry.

Through these halls the chemical knowledge of the past and the acquisitions of the future will flow in and out. In from all the world, in from the accumulated stores of the past and from all the future sources, out again in widening circles as far as truth can reach. But this laboratory as a center of chemical learning will not be simply a mirror reflecting only what it receives; but by its own investigations it will add to the mirrored truth its own flame of creative research.

If it is inspiring to take part in the launching of a new ship, to imagine the seas it will sail, the ports it will visit, the cargoes it will carry—how much more inspiring at the inauguration of this new laboratory to think of the minds that will be influenced here, of the new truths that will be taught and learned, of the discoveries that will be made which we cannot even imagine now. The science of chemistry sails no charted seas, she has no fixed ports nor cargoes. She sails the high seas of discovery, her destination no man can foretell; her outlook is toward an unbounded horizon, her cargo is the fruits of garnered knowledge and of future investigation.

In concluding these remarks allow me the honor of paying a highly merited tribute to the Director of this laboratory and to his able coworkers. This university has recognized that no building however great can be substituted for a staff competent in research and instruction. It has been wise in first insuring and maintaining adequacy in those respects. Brains and ability must always come before bricks and mortar. This new laboratory should, therefore, be regarded as a monument to those who have had the vision and the ability to bring it into being, not a dead monument of past grandeur but a living one of present activity and of future achievement.

Finally, it is my privilege to bring you greetings from the School of Chemistry of a sister state which also occupies a splendid building, a worthy monument to its able ex-director, recently become emeritus.

I congratulate the University of Colorado, and especially the students and faculty of the Department of Chemistry upon the facilities provided by this new building and its splendid equipment. To students and faculty both come the advantages and responsibilities of their use. I wish you God-speed in employing them to carry on the cause of chemistry in this great mountain empire so abundantly endowed with nature's stores which through the researches and application of chemistry are being brought forth to augment the riches of the world.

Eminent Scientists Search for Pyorrhea Cause. Diet rather than germs may be at the bottom of pyorrhea. Experiments conducted by some fifty members of the faculty of the University of California and their assistants, who have been working on this acute dental problem of modern life for the last two years, show that a condition resembling pyorrhea can be produced in animals and men by "slight upsets in the acid-base balance of their diet."

Funds to the extent of $100,000 have been supplied for this work by the Carnegie Corporation and various dental societies.

Since most of the previous research on pyorrhea has been along bacteriological lines with the hope of implicating as the cause some particular germ that could be run down and exterminated, the nutrition angle on the problem that the experiments have revealed has awakened great interest.

As a consequence of these new facts the Carnegie Corporation has, at the request of the committee in charge of the dental research, sent to consult with the California workers a group of authorities on physiology and nutrition, consisting of Dr. Lafayette B. Mendel of Yale University, Dr. Elmer V. McCollum of the Johns Hopkins University and Dr. Edward H. Hatton of Northwestern University Medical School.—*Science Service*

"Animal Magnetism" Photograph Duplicated with Rubber Glove. Another "psychic" phenomenon, backed up by photographic evidence, has been upset with nothing more than a rubber glove filled with water, plus a common alarm clock.

Dr. Julius von Ries, a well-known physician, tells of a woman living at Geneva who believed that she was possessed of the power of "animal magnetism," and practised the laying on of hands to cure sick people. In an effort to learn whether any physical emanation actually did come out from her hands, she laid her left hand on a covered photographic plate and kept it there for half an hour. After development, the plate showed a luminous print the size and shape of her hand, with what seemed to be short rays streaming out.

Dr. von Ries was somewhat skeptical. He tried the experiment over again, and got the same luminous print. Then he substituted a rubber glove filled with warm water for the living hand, weighted down with a running alarm clock to simulate the pulse—and again got the same pattern. Finally he used a glass vessel filled with water and weighted down with the clock, and once more got a print, this time the shape of the bottom of the glass. He concludes, therefore, that the photographic effect is not psychical but physico-chemical. The warmth of the hand or of the water reduces the sensitive silver salt on the photographic plate, and the slight shaking due to the pulse or the ticking clock makes the pattern fuzzy, giving the appearance of rays.—*Science Service*

KUNCKEL AND THE EARLY HISTORY OF PHOSPHORUS

TENNEY L. DAVIS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

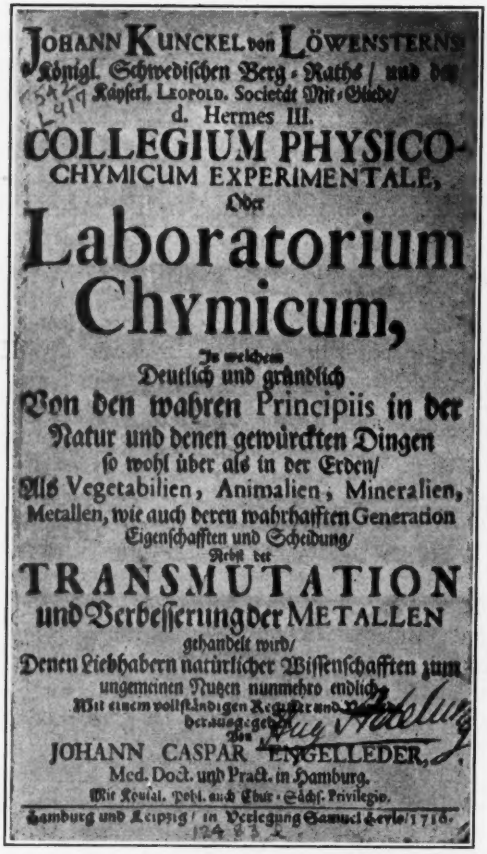
The discovery of phosphorus followed soon after the discovery of the induced phosphorescence of certain calcium salts, and had an enormous effect not only upon the minds of chemists but upon the imaginations of intelligent people in general. The new substance shone continuously in the dark, inflamed on slight provocation, burned with a flame extraordinarily brilliant, and wasted away entirely unless it was kept under water. It was exhibited at the courts of princes. It was cried up as a remedy for serious ills. And the everlasting wonder of it was set forth in writing and in pictorial art.

Phosphorus appears to have been first discovered by the alchemist Brand of Hamburg, who was unwilling for a time to disclose the method of its preparation. Kunckel saw Brand's material but found it impossible to do business with him, and proceeded to discover for himself the manner of preparing it. It came to be known as *Kunckel's phosphorus*. Robert Boyle seems also to have worked out independently the means of producing it, and in 1680 described the method in a paper deposited with the Royal Society but not published until 1682. Ambrose Godfrey had a hint of the process from Boyle and is reported to have supplied Europe with the article. Hence it was frequently known as *English phosphorus*. The whole early history of phosphorus would make an interesting study. The study would be a book, and the book would be an historical romance. The present paper deals merely with Kunckel's part in the history.

Johann Kunckel (1630–1703) was one of the most competent chemists of the seventeenth century. An exceptionally able experimenter and acute observer, he contributed many new facts to chemistry. He discovered mercury fulminate and nitric ester, and is best known for his work on ruby glass and on fulminate. His treatise on glass-making remained the best work on the subject until nearly the end of the eighteenth century. He was employed by various German princes and finally by Charles XI of Sweden by whom he was made Baron von Löwenstern and Councillor of Mines for the kingdom. His most important work, the LABORATORIUM CHYMICUM,[1] was published after his death, under the editorship of Engelleder—and was the source from which Karl Wilhelm Scheele imbibed his first rudiments of chemistry. It is a book to awaken an enthusiasm for chemistry, for it gives a racy account of Kunckel's experiments and adventures.

[1] First edition, 1716. The book has a frontispiece portrait of Kunckel, less interesting than the more lively portrait, reproduced herewith, which is the frontispiece of his *Ars Vitraria Experimentalis*, published during his lifetime, in 1679.

In the Third Part of the LABORATORIUM CHYMICUM, Chapter 34, pages 649–665, the author gives an account of the two chemical discoveries which he considers to be the most important of the century. They are the discovery of ruby glass, which was developed by Kunckel from the purple of Doctor Cassius, and the discovery of phosphorus.



JOHANN KUNCKEL von LÖWENSTERN/
Königl. Schwedischen Berg-Raths / und der
Käyserl. LEOPOLD. Societät Mit-Glieds/
d. Hermes III.

COLLEGIUM PHYSICO-CHYMICUM EXPERIMENTALE,
Oder

Laboratorium Chymicum,

In welchem
Deutlich und gründlich
Von den wahren Principiis in der Natur und denen gewürckten Dingen so wohl über als in der Erden/
Als Vegetabilien, Animalien, Mineralien, Metallen, wie auch deren wahrhafften Generation Eigenschafften und Scheidung/
Nebst der
TRANSMUTATION und Verbesserung der METALLEN
gehandelt wird/
Denen Liebhabern natürlicher Wissenschafften zum ungemeinen Nutzen nunmehro endlich
Mit einem vollständigen Register
herausgegeben
Von
JOHANN CASPAR ENGELLEDER,
Med. Doct. und Pract. in Hamburg.
Mit Königl. Pohl. und Chur-Sächs. Privilegio.

Hamburg und Leipzig / in Verlegung Samuel Heyls / 1716.

Kunckel's account of the discovery of phosphorus—I include the adventure with Balduin and the phosphorescent calcium nitrate for the sake of completeness—is as follows.

In the year 1677 there lived at Grossen Hahn in Saxony a certain bailiff of the name of Balduin who was a learned, curious, and clever man, and who had a company with Doct. Früben who was *Medicus* at the time, for both of them were fallen on the *Spiritus Mundi*, as they called the material, which they were able to collect and to use by means of a certain magnet. For this purpose they took chalk, dissolved it in spirit of niter, evaporated to dryness, and left the residuum in the air so that it attracted water to itself. This they abstracted, and they said that the water was a *Spiritus Mundi*. A *loth* of it was valued at 12 *groschen*, and was used by high and low.

Here it can readily be perceived that the belief must have come to fill the place of the effect—for mere rain water would have worked as well. In the course of this work it happened by mistake that the spirit of niter was once evaporated to a hard mass, and consequently that something yellow collected in the neck of the retort. After it had been broken indoors, he threw the neck into a dark corner of the laboratory where he remarked that it glowed like a coal. He observed the phenomenon with wonderment, and remarked further that this light faded again in the dark and took on light again from the sunlight. With this then he came forthwith to Dresden to the Lord Director of the Privy Council, Baron von Frisen, then

to almost all the principal ministers, and finally he came to me. I must acknowledge that I had to marvel greatly at it, but was not able to be so fortunate as to contrive to get any of it into my hands. Finally, impatience drove me to seek him out—and he treated me in a perfectly courteous manner to agreeable music until evening time, for

Wissenschafft Erfahrenheit u. Verstand von allen Sachen,
Wollten diesen rechrten Mañ nunmehr unvergleichlich machen:
Und die Warheit, die das Ziel vor nach sehe augen funckeln!
Er Amt mit hohen Adel schon dessen Nahmen JOHAN KUNCKELN.

he excelled on many instruments. I had now discoursed with him for a whole day, but his discourse was as orderly as a swarm of bees.

After a light was brought, I asked him if he hadn't observed whether his phosphorus (for so he had baptized it) would not absorb to itself the light from a natural light as well as that from the sun. This was tried, and succeeded when the material was held

close to the light. But all the same I couldn't yet get it into my hands. Finally I asked if the light from a greater distance couldn't be thrown into it still better by means of a concave mirror. Full of enthusiasm, he left to fetch one, and in his haste forgot his piece of retort—which I consequently examined, and I twitched off a little of it and put it into my mouth. Then he returned with the mirror. I asked if it couldn't be communicated. He said, yes, if I should wish to accept the conditions which they would impose on me and would join their society, then it could be done very well. But the conditions were such that they didn't suit me in the least. In sum, I left the matter unsettled, but sent a messenger forthwith to Dresden to the blessed Tutzky, who had been assisting in the laboratory for a long time, and wrote him to make the solution with chalk without delay (for we knew that he used chalk and spirit of niter), to evaporate it directly as strongly as possible, and to let me know the outcome soon by a messenger, while I was still engaged in overtures with him.

This Tutzky, who was also impatient to learn about the matter, speedily smoked off the spirit, put some of the residue on a small capsule under a muffle, cooked off the substance, and produced a yellow crust. There we had the phosphorus. In the meantime I was invited, with the bailiff Balduin, to the mid-day meal at the home of Imperial Privy Councillor von Frisen, who was head bailiff at this place. This gentleman was curious and, as a member of their society, he also knew what sort of conditions they had laid down for me. Among other remarks, the Baron offered the bailiff his spare coach if he had anything to arrange at Dresden. Whereupon I asked if I might not go along with them. Then the head bailiff addressed the bailiff in Latin; he thought we ought first to make a contract. The bailiff made answer that I should not escape his observation; there was still time enough; I was impatient about it; the Baron ought to be on his guard with me and Tutzky—we were both shrewd customers. I had to laugh inside that they thought I didn't understand as much Latin as that. However, I didn't allow myself to show it, but went forward. When I mounted the coach, the messenger stood there with the phosphorus which he had brought me. I forthwith wrote a note for the courtesies which he had shown me and sent my phosphorus to him as a token of thanks, while he was even then engaged in a lively meeting of their society.

The intelligent reader can readily imagine how welcome this letter was. On the strength of it he came to us at another time at Dresden and asked if we would still let him have the honor of the discovery, and would not divulge it. This I have made good. We also had to tell him how we had prepared it in a test capsule. Then he made a large amount of it, covered it over with glass, and sold it at Leipzig. He also sent emblematic pieces to various courts—and he had good profit. In this business I didn't meddle with him in the least, although he was inwardly very spiteful to me. He actually made his things larger than he needed to—because he was so honor-seeking. And all the time I was an obstacle in his way. When he had written his *Aurum Aurae*, I asked him how he could have the heart to talk up such things to the world. Didn't he see with his eyes that it was natural verdigris, that the keg or sack of some carrier who had had to carry it from Leipzig to Bresslau had become loosened, or a hole might have been worn in it, so that it was thence scattered about in the highway? An intelligent person would surely have asked, why came it to be only on the highway, and not scattered about in the fields and barnyards, if it had fallen with the rain in a thundershower? Now didn't he find for a fact that it gave copper, etc.? Then I suggested the answer: Thus must people be made fools of. But I leave it undecided whether that is right. This is now the whole adventure of this phosphorus by which it acquired its name.

. . . . .

The just-described phosphorus was scarcely a few weeks old when I was obliged to

make a trip to Hamburg, and I took one of these glowing fragments along with me. I let someone see it who told me, "There is a man here, called Doctor Brand, an unsuccessful merchant who has applied himself to medicine, who has recently made something which glows continuously in the night." This friend also brought it about that I should become acquainted with him. I was curious to see it, but he didn't at that time have any ready except a little which he had given to a good friend—and that I got sight of. Now he had obtained it readily, and in the beginning had done little work on it until he had seen that I was curious about it. I stayed around, but it was always one delay after another. In the meantime I had written to Herr Crafft at Dresden, and he, as soon as he received my letter, took the post, and, unbeknown to me, came to Hamburg and sought out this Brand, while he and I were still negotiating, and gave Brand 200 *Reichsthalers* on the condition that he should not inform me about it and should make a few *loth* of the material for him.

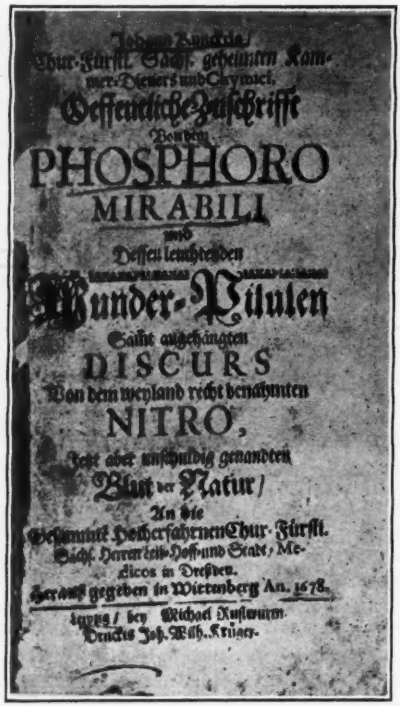
Of all this I knew nothing at all, not even that Herr Crafft was in Hamburg. As I now supposed that this Brand would show me all, I went to his chamber—and Crafft at the time was inside with him. He came outside, and excused himself that he couldn't invite me in; his wife was sick at the time, and he still had someone with him. He said further that he couldn't teach me the art. He had wanted to make it again but had not been able to accomplish it. All these pains were spent, so I judged, in order that I might go away empty in consequence. But since he had made it known to a certain woman, and also to me, that it came from urine, I thought that I should accomplish it perfectly well. So I had to go away from Hamburg without success, and was not able to acquire the secret.

But, before I went away, I chanced to meet Herr Crafft and told him the story. He straightway swore by stone and bone that I would get nothing, for the fellow was very obstinate. I did not know that this B. had finally promised him that he would not disclose it, either to me or to any man, until a certain time, for he had deposited it with the chaplain of the Pest House as a bond. So I had to travel along.

I wrote from Wittenberg and asked him once more, and he gave the same answer as in the first case—that he could not accomplish the process himself. I persisted. Then he wrote that he had again, by a special dispensation of Providence, discovered the trick (such was the skill of the man), but, because of certain conditions, he couldn't disclose it. Thereupon I again wrote him that I would try my hand at it; and, since I could not get it from him, that I should consequently be under no obligation to him if I should discover it for myself. Upon this he wrote me in substance as follows: "I have received the gentleman's letter and see from it that he is half good and half defiant," etc.—and informed me that he had been under the necessity of meeting the wishes of Crafft who had given him 200 *Reichsthalers*, but after this he had learned that Crafft had already benefitted somewhat by it at the court of Hannover, and, as he had not treated him rightly, he had bidden him farewell and was willing therefore to negotiate with me. But, if I should discover it, then I ought to recall my promise to him, what I had offered him, etc. Wasn't this a sensible request? I had given him as many fine words as I had ever given during my life to any man, but nothing was to be learned from this *Doctor Medicinae et Philosophiae*, as he inscribed himself, and now he wished to obligate me to pay him something if I should discover it myself.

Meanwhile some weeks elapsed; I grudged neither labor nor expense, and was soon so lucky as to discover it and to bring it to the point. The beloved reader has here surmised the true event, that he taught me nothing. Moreover, if he had taught it to me and had at the same time taken 200 *Reichsthalers* from Crafft with a sworn agreement not to teach it to me, then he had behaved like a perjuror to Crafft, and Crafft could indeed have asked back his 200 *Reichsthalers*. I have heard that this *Doctor Teutonicus*

railed at me in a frightful manner, but I don't know whether it is true. Besides, what could be expected from such an impoverished *Doctor*, who had commercialized his study and in consequence knew no word of Latin! Once, when his child's eye was bruised, I told him that he ought to apply a little *Oleum Cerae* so that it wouldn't turn blue. He replied, "*Wat is dat?*" "Oil of Wax," I answered. And he said in his good Hamburgish, "*Sü, Sü, dat is ock wahr, ich bedacht mi nicht so balde.*" Hence I have justly styled him *D. Teutonicus*. After his dealings with me, he finally made his secret so common that he accepted 10 *Reichsthalers* for it in his poverty. He taught it to an Italian, who came to Berlin and dealt in processes after the foreign manner, who charged 5 *Reichsthalers* for the secret and taught it to anyone who wanted it. But I have a trick herein, which no one yet knows, which is this, namely, to make this phosphorus perfectly clear like a crystal and of greater strength than otherwise. But I don't make any anymore, for a lot of mischief can come from it.


Johann Kunckels/
Chur-Fürstl. Sächs. geheimten Kammer-Dieners und Chymici.
Oeffentliche Zuschrifft
Von dem
PHOSPHORO
MIRABILI
und
Dessen leuchtenden
Wunder-Pillulen
Samt angehängten
DISCURS
Von dem weyland recht benahmten
NITRO,
Jetzt aber unschuldig genandten
Blut der Natur/
An die
Gesammte Hochverfahrne Chur-Fürstl.
Sächs. Herren Räthe Hof- und Stadt-Medicos in Dresden.
Herausgegeben in Wittenberg An. 1678.
Leipzig/ bey Michael Rußwurm
Druckts Joh. Wilh. Krügern.

In his OEFFENTLICHE ZUSCHRIFFT, etc. (Open Letter on the Phosphorus Mirabilis and on Its Glowing Wonder Pills), published in the year following these adventures, Kunckel describes the properties of phosphorus more fully but comes no nearer to describing the method of its preparation. He had first obtained phosphorus in the form of a "black soap" which glowed in spots and did not shine continuously. He says—

A little of this soap ground up in clear water and shaken about gives a very pleasing light, and some of the particles which remain attached to the glass above the water flash and twinkle like little stars.....

This soap has the property that gunpowder put with it and merely left in the warmth of the sun, takes fire of its own accord. Likewise, if only a little is scraped off on the finger and warm gunpowder is touched with it, the powder goes off—as I have had the very distinguished pleasure of demonstrating to persons of consequence in the principal cities.....

A man can write on paper with it, and, if he has a piece only as large as the head of a small pin, he can make an unbelievable light back and forth with it on the paper until the little grain is worn off and cannot be seen.....

When this *Smegma*, or the grains, is rubbed with the finger and the hair is stroked

with it in the night, each hair gives off a glow—and, once seen, is a thing to be remembered.....

If one writes on paper with it and folds the paper to four thicknesses, it shines through all the leaves. But if one presses them too strongly, the paper takes fire because of the *motum*.....

Further, I have something on another subject; a thing which is like an oil and can be used with a pen for writing.—If, in writing, the pen is pressed a little too hard, the paper takes fire. Now this, more than the other, has a wonderful, secret, hidden power, and so must be guarded against the air or kept under water in order not to waste away entirely.

I have something on still another subject; a thing which is so subtle that, if it is allowed to warm up on the bare hand, it forthwith inflames and gives a furious fire. The residuum, which is left behind, shows an orange color and flashes and shines like the *Smegma*.

The last-quoted passage appears to contain the earliest known reference to the red modification of phosphorus.

Kunckel even recommended pills of phosphorus for internal use, and coated them with gold and silver—evidently by allowing the pills to stand in contact with solutions of these metals. He apparently noticed that this treatment increased the weight of the pills and concluded that it therefore increased their efficacy, for he points out, in passing, that fulminating gold weighs more than the gold from which it is made and hence that this same (whether the increase of weight or the fulminating power is not clear) comes from the menstruum.

When fulminating gold is made, the same gold comes out heavier than it weighed before, not that the gold is heavier but that the same comes from the menstruum, as I have already set forth in my earlier treatise.....

I am the first to have devised a method for producing conformance-pills which are gilded and made from the rarest portions of this Wonder-Light, which are proper for the health of man, and compounded with my spirituous gold essence as well as with certain other things. One or two of these pills taken evening and morning will save a man, with the help of God, from all fear of apoplexy or of other sudden sickness during the day. They counteract all noxious and poisoned airs and are a right *Antidotum* against the pestilential poison. They strengthen and support the vital spirit in man....

If a man has an inner pain and no rest from it, let him take, according to the convenience of the person, one, two, or even three, and, before an hour has gone by, he will perceive the singular effect of them. They will not only allay the pain but, in a singularly remarkable manner, without damage, will supply the needed rest.....

They cause no vomiting nor any inconvenience but act in a mysterious manner and are applicable in serious sickness and pain.....

To little children of a few weeks of age, who frequently cry night and day and have no repose, let there be given a half or, according to the age of the child, a whole, of one of these pills in mother's milk or in clove (?) water, then the singular effect will appear that the pain is allayed and the child comes to repose.

The third chapter of the "Open Letter" describes the Phosphorus Mirabilis or Wonder Stone, which no doubt was the wax-like phosphorus, "perfectly clear like a crystal and of greater strength than otherwise,"

which Kunckel claimed as his own particular secret. The products were on sale at Leipzig at the apothecary shop of Heinrich Linken who charged 3 *Reichsthalers* for a piece of the "stone" and one *groschen* for a pill.

Although Kunckel did not disclose the method for the preparation of his phosphorus, there seems every reason to believe that he accomplished it, as did chemists for some time after him, by evaporating putrid urine to the consistency of sirup, mixing with sand or brick dust, and distilling at a high temperature from a fortified (coated with clay) retort, the beak of which delivered under water in the receiver. The silicic acid of the sand or brick dust liberated phosphoric acid from the phosphates of the urine, and this was reduced by the carbonaceous material which was present.

Boerhaave in his ELEMENTA CHEMIAE[2] tells a good story about phosphorus, a story which shows the imaginative appeal of the marvelous properties of the substance. As the story also contains a moral, and as a moral is commonly accepted to be the proper ending of a romance, the story may fittingly supply an ending to the present contribution to the romance of the early history of phosphorus.

There is a story of a Tutor, who after all other endeavours to no purpose, by a contrivance borrowed from Chemistry, happily reclaimed a noble youth, who by his dissolute life brought disgrace both upon himself and family, and seemed past all hope of amendment; and this was in the following manner: One night as he lay in the same room with this young Gentleman who was fast asleep, he got out of bed softly, and with some English Phosphorus wrote his name in large letters on a board that was at the foot of the bed, and added three words, intimating that if he did not immediately repent, he must expect to die in a very short time. When he had done, without disturbing his pupil he stole gently to his bed again, but then made a great noise on purpose to wake him, and laid himself down as if he was asleep. The youth presently started up in his bed, and listened attentively in order to discover the occasion of his surprize, but heard nothing except the snoring of the other, who feigned himself asleep; but looking accidentally towards the foot of the bed, he saw some letters shining with a blue light which vastly astonished him. Upon this, he calls to his companion, and shews him the writing; who making as if he knew nothing at all of the matter, professed that he did not see anything, which so much the more increased his terrour. The servants who were not in the secret, were then called to bring in some candles, upon which the letters disappearing, they declared, too, that they saw nothing; and indeed the youth himself was astonished to find that the writing was vanished. The servants went away again, but left a candle which happened to shine upon the board; the tutor sets down by his pupil and persuades him to go to sleep, tells him 'twas only a dream, and then goes to bed himself, and puts out the candle. As soon as ever the room was dark, the youth no sooner looked towards the fatal place, but he again saw the same letters, at which being vastly frightened, he cries out, and begs his tutor to come to him; who then pretending himself to be afraid, confessed that he did indeed see the writing, and that not without a great deal of astonishment; and then took this occasion to admonish him sincerely to

[2] Boerhaave, "Elementa Chemiae," Ludguni Batavorum, **1732,** vol. I, pp. 106–107. The English is from Dallowe's translation, "Elements of Chemistry: Being the Annual Lectures of Herman Boerhaave, M.D., etc." London, **1735,** vol. I, pp. 66–67.

repent, in obedience to this Miracle, and calling for a candle spent the remainder of the night with his pupil, who was under great concern, and was brought by this means to a better way of life.

Sweet Potatoes for Alcohol in China. Cheap sweet potato wine and beer may become the Chinese national drinks if recommendations made by Nanshiu Wai at the recent Pan Pacific Science Congress to increase the sweet potato yield of China as a source of alcohol production are adopted. Uncultivated sandy regions in Chekiang Province can be made to blossom with sweet potatoes to great advantage to the brewing industry, he stated. The result would be much cheaper alcohol than what is now imported from Hawaii and Cuba, where it is manufactured from sugar-cane molasses.

There would be a yield of 73,143 tons of 97 per cent ethyl alcohol from the 468,000 tons of potatoes that could be raised in this territory and the 44,000 tons which is now the annual crop in Chekiang, Mr. Wai said.

"The points in favor of converting potatoes into alcohol," he stated, "are that potatoes are cheap, that they will yield a good spirit, that the residuals may make a good cattle food, and that they require a minimum of yeast."—*Science Service*

Fruit By-Products Used for Dairy Feeding. By-products of raisins and oranges can now be used for feeding dairy animals, according to a statement from the University of California, with assurance of good results.

It was reported by the Exchange Orange Producers that for a single year there was a by-product of 9000 pounds of pulp, and it was computed that by 1930, 50,000 pounds would be wasted from oranges in a single orchard section. Use was sought for this material.

The experiment station used sheep in the tests. Alfalfa was mixed with the pulp for feeding. In the case of raisin pulp it was found that digestibility equaled about two-thirds the value of barley or beet roots, while with the orange pulp the value was approximately the same. Dairies situated near factories where oranges or raisins are made up into jellies, marmalades, sirups, and other products are profiting from reduced cost of feeding.—*Science Service*

Different Germs Produce Same Poison. A close and curious relationship between scarlet fever and erysipelas has been brought to light as one of the immediate results of an exhaustive investigation now under way in the laboratories of the New York City Health Department.

Certain strains of scarlet fever germs, it has been found, produce a toxin, or poison, in the fluid in which they are bred that is identical with the toxin produced in the fluid by certain strains of erysipelas germs. Different toxins, however, are found within the germs themselves.

The toxin in the fluid that holds germs is known to bacteriologists as exotoxin. The toxin found within the bacteria cells is called endotoxin. Thus these strains of scarlet fever and erysipelas germs produce a similar exotoxin, but their endotoxin differs. Therefore, antitoxin for one of these diseases will not be a protection against the other disease. In fact, in the case of erysipelas, according to Dr. William H. Park, director of the Bureau of Laboratories, there are at least two distinct groups of germs with equally distinct endotoxin. So an effective antitoxin for erysipelas must be made from both groups of erysipelas germs.

The discovery of this relationship between scarlet fever and erysipelas is at present of no practical value to medicine but it points the way for further investigation which may mean still greater victories in man's fight against the bacteria that invade him.—*Science Service*

THE RELATION OF CHEMISTRY TO HEALTH AND DISEASE*

WILLIAM MCWHORTER LOEHR, WAUKEGAN TOWNSHIP SECONDARY SCHOOLS, WAUKEGAN, ILLINOIS

Louis Pasteur in his address[1] before the French Academy of Sciences April 29, 1878, commences his memorable paper, "The Germ Theory and Its Application to Medicine and Surgery," with the sentence—"The Sciences gain by mutual support." It must be conceded that it is only in comparatively recent years that the two noble sciences of medicine and chemistry have stood shoulder to shoulder pushing aside the boulders of ignorance and superstition. Ever guided by the humanitarian point of view these related sciences have vigorously encouraged united research; the ultimate outcome of which has been the saving of thousands of lives from abnormalities, the lifting of countless thousands out of the dark shadow of sickness into the sunlight of good health, and the making of life longer and happier to the great masses of people.

WILLIAM MCW. LOEHR

That chemistry is valuable to the modern physician is indicated by the increasing demand for more training and study in the basic and fundamental principles of this science. We find the investigators, pioneer medical men of the old school, returning to the universities in great numbers to pursue further this study, that they may undertake more scientifically the development of their investigations. We find the major universities throughout the land demanding of the already overloaded medical student double and treble the former requisites in this fundamental science. Such demands show the imperative necessity of well-grounded instruction in chemistry and conclusively prove the prophetic words of H. A. Rowland, the renowned American physicist, when he said, ". . .All the sciences are linked together and must advance in concert. The human

* Prize-winning high-school essay, 1926–27.

[1] Published in *Comptes Rendus de l'Academie des Sciences*, **86**, 1037–43 (1878).

body is a chemical and physical problem and these sciences must advance before we can conquer disease."[2]

Pursuant to these words the present-day chemist is ever at work aiding the physician. The mutual grounds in which he has commanded the attention of the world (scientist and layman alike) are: (1) combating disease with aniline dyes, (2) the production of synthetic drugs, (3) the preparation of anesthetics, (4) development of antitoxins, (5) researches on metabolism and vitamins, (6) use of radium as a curative agent, and (7) the researches on the endocrine system of the body.

Of these seven fields for coöperation between chemist and physician, it is impossible to select the most important, so varied have been their applications. But one of the greatest additions to the medical armamentarium is the ability to use aniline dyes, coal-tar derivatives, in the curing of infected wounds and in combating septicemia. The chemists, who during and after the World War worked unceasingly to produce the kind of dyes which are responsible for the many luxuriously colored costumes, were at the same time unintentionally rendering invaluable assistance to medical science.

These dyes first found their way into medical laboratories a few years ago by their use in staining microörganisms for study. It then developed that certain dyes caused certain germs to be inhibited or killed. From the observance of this phenomenon came the theory that what had taken place in the laboratory could also be successfully accomplished in the human body. Upon further investigation, the dyes inhibiting the bacteria known as staphylococcus aureus, streptococcus hemolyticus, and streptococcus viridans were found to be the dyes known to the chemist as acid fuchsine, acriviolet, acriflavine, gentian violet, and mercurochrome.

It is hoped that in addition to their germicidal quality, these dyes will prove to possess an inhibitory power within the body. In connection with this possibility there is on record a case in which, when an acriviolet-soaked gauze had been inserted into the wound at a mastoid operation, the tissue in the sinus of the post-operative wound was quite sterile at the first dressing ten days after the operation, thus demonstrating the possibility of leaving an antiseptic within a highly sensitive cavity, a course of action impossible with iodine or bichloride of mercury.[3]

Even though the problem of conquering infection with aniline dyes is still open to much research and experimentation, former investigations in this field have proved to be the "Open Sesame" for further contributions to medical science.

As an outgrowth of his synthesis of aniline dyes from coal tar the chemist has actually worked wonders in the synthetic production of

[2] H. A. Rowland, *Am. J. Sci.*, **8**, 409–11 (1899).

[3] *Scientific American*, Nov., **1925**, p. 303.

drugs. The first coal-tar drug to be of use to the physician was antipyrin. Produced from aniline in 1883, by Knorr of Germany, antipyrin has proved successful as a substitute for quinine in curing common coryza. From the same experimenters came the discovery of acetanilide prepared from aniline by treating the latter with acetic acid. Other coal-tar drugs are the soporifics such as veronal, medinal, and sulfonal. The chemist accomplished a most remarkable victory in drug synthesis when he extracted from chaulmoogra oil the acids whose ethyl esters are the curative principles for the long-dreaded disease, leprosy. As A. Frederick Collins[4] says in his book, "Wonders of Chemistry,"—"The chemists have acquired, what is called in physics, momentum, and having got a good start nothing can stop them in their efforts to duplicate nature's drugs and to make new ones."

This momentum broke down the barrier to coöperation between chemists and physicians, and swept them into the sphere of their combined efforts to produce anesthetics. The use of some form of soporific drug as a substitute for anesthesia dates back to antiquity. The soothing Egyptian nepenthe which Helen casts into the wine for Ulysses in the Odyssey, the "samme de shinta" of the Hebrew's Talmud, the "bhang" of the Arabian Nights, and the "drowsy drops" of Shakespeare's time are all examples of legendary anesthetics.

Dioscorides, the originator of the materia medica, tells in his therapeutic works of the soporific virtues of mandragora wine which proved to be a substitute anesthetic during the Middle Ages.

Another medieval alternate was the formula of the "spongia somnifera." Concerning the "spongia" the medical historian Garrison[5] says—"The sponge was steeped in a mixture of opium, hyoscyamus, mulberry juice, lettuce, hemlock, mandragora, and ivy, dried, and when moistened, inhaled by the patient, who was subsequently awakened by applying fennel-juice to the nostrils." This method of bringing about insensibility was in vogue up to the seventeenth century.

During the Renaissance period a Prussian physician-botanist of note, Valerius Cordus, discovered sulfuric ether (1540), to which he gave the name, *oleum dulce vitrioli*. The anesthetic value of ether at that time was given little or no consideration; for chemistry, such as it was, became incorporated in the fortune-hunting cult of alchemy, which was so engrossed in the search for potable gold, the philosopher's stone, and the elixir of life that it had little time for the work of true scientific value. Further research on the subject was not undertaken until the middle of the nineteenth century, when William Morton, a student of an able chemist,

[4] A. Frederick Collins, "Wonders of Chemistry," Thomas Y. Crowell Co., **1922,** p. 218.

[5] Fielding H. Garrison, "History of Medicine," 3rd edition, p. 143.

used chloric ether in filling a tooth. Continuing his inquiries, Morton learned of the anesthetic value of sulfuric ether, which he applied in extracting a bicuspid of one of his patients. Convinced of the anesthetic value of ether he confided his results to a physician of the Massachusetts General Hospital, with whose coöperation ether anesthesia became an important factor in operative surgery. The modern chemist's improvement of nature's cocaine by producing novocaine, beta-eucaine, and apothesine has greatly ameliorated human suffering and added another recent and praiseworthy triumph to the science of chemistry.

To this science also, the medical profession and the world at large owe a debt of never-ending gratitude through the personage of one of the most versatile geniuses the world has ever known—Louis Pasteur. Chemistry well-nigh reaches its Utopia through the researches of this man alone. His overthrow of the incredible theory of "spontaneous generation," and his subsequent establishment of the doctrine of bacterial infection is one of the truly epoch-making discoveries in chemical and medical history. He laid the foundation for Lord Lister's antiseptic surgery—surgery as we know it today. Pursuing his investigations he developed an antitoxin containing the specific agent of rabies. Though not a physician he conclusively established its clinical value. As a result of this work we find two new sub-branches of medical science, bacteriology and immunology, founded by this eminent chemist, which have made unlimited advancement, and stand today the conquerers of some of the greatest scourges of the human race—diphtheria, typhoid fever, meningitis, and pneumonia. With such remarkable progress before them, the biochemists of today are seeking the pure active principles of the various antitoxins, vaccines, and serum mixtures, the outcome of which will be refined and improved vaccines doing away with a preponderance of useless impurities now injected into our veins and tissues. This problem of separating the minute amount of pure active principle which must be present in all serums is in its infancy and is one of great moment in chemo-medical research.

Physicians and chemists have again demonstrated the feasibility of their coöperation, in the furthering of our knowledge of the metabolic processes of the body and the chemo-pathological action of the vitamins. To Frederick Gowland Hopkins, praelector of biochemistry at Trinity College, goes the honor of having first observed that a diet lacking in the amino-acids, arginine and histidine, will fail to maintain life.[6] Based upon this early observance of the importance of vitamins, a scientific explanation of such deficiency diseases as polyneuritis, rickets, scurvy, and beri-beri was later evolved. One of the greatest of European chemists, Emil Fischer, laid the foundation for the modern study of the metabolism

[6] Fielding H. Garrison, "History of Medicine," 3rd edition, p. 604.

of proteins, a knowledge of the chemical changes occurring in digestion, which is of infinite value to the physician at the bedside. We must, therefore, look to the chemist to furnish additional data on carbohydrate and protein metabolism, and a more exacting research of the comparatively new field of food analysis with special reference to vitamins, and perhaps show how certain vitamins may be synthetically produced.

The study of vitamins and metabolism has enabled humanity to maintain good health better than ever before through preventive measures. But when preventive measures have not been sufficient as in the case of cancer, an exceedingly prevalent disease and still of unknown etiology, the method of cure has been successfully used due to the work of that brilliant woman chemist, Mme. Curie of France, who discovered the powerful metal known as radium. To this scientist has gone great commendation from both chemical and medical circles, for very shortly after its discovery radium was found to create the same action on the tissues of the body as the X-ray. Thus, chemists made possible a radium therapy by the preparation and purification of radium salts. These salts have the ability to render malignant growths and neoplasms *impotent* without damaging healthy tissues. Radium affords the physician a means of curing cancer in certain body areas unapproachable to the surgeons' knife; therefore, each hospital has come to possess its own small tube of radium salts.

While researches are going on to extend the use of radium in the cure of one prevalent disease, the curative agencies have been widened by the biochemists in another field, the endocrine system, to include diseases, especially those due to wrong chemical and physical conditions of the human body.

Diseases brought about by faulty function of the endocrine system of the body are diabetes, exophthalmic goiter, cretinism, and diseases of the pituitary gland which result in dwarfism, giantism, and other malformations of the body. Only a score of years ago these diseases were known as "idiopathic" or of unknown origin. But biochemical research has unveiled their causes and laid the foundation for further prevention and cure.

As far back as 1774 the theory of internal secretions had been advanced. In that year Theophile de Bordeau published his theory of internal secretions resembling very much our modern theory of "hormonic equilibrium." However, the true starting-point of the doctrine of internal secretions dates to the works of Bernard and Addison (1848–1855). In 1903, Charles de M. Sajous, of Philadelphia, advanced a system of medicine based on the endocrine system, in which the suprarenal, pituitary and thyroid glands were said to control the immunizing mechanism of the body.

With the researches of a half century before them, Drs. Banting and Best with the aid of Drs. Macleod and Collip set about finding a treatment for diabetes,[7] a disease manifested by the inability of the body to take care of carbohydrates and sugar due to a degeneracy of the islets of Langerhans in the pancreas. Thus their task lay in finding an extract of the islets of Langerhans with which they could replace the diseased pancreas; *viz.*, they must attempt to raise the diabetic food tolerance by the use of a pancreatic extract. They at last succeeded in producing insulin, the beneficent results of which are familiar to thousands of diabetics, and which was made possible through the researches of hundreds of scientists in the biochemical laboratories throughout the world. The pathologist, the physiologist, and the chemist, each contributed his quota of fundamental information.

Dr. Collip, the chemist who aided Drs. Banting and Best in the isolation of insulin, subsequent to that work has successfully completed a series of investigations which have finally led to a "stable and standardizable" extract from the parathyroid glands, which lie just behind the thyroid gland. The parathyroid hormone has a profound influence on the regulation of the amount of calcium in the blood.[8] This extract has proved beneficial in any condition in which the secretion of the parathyroid glands is deficient. Great possibilities are entertained for this extract in aiding recovery from post-operative tetany, spasmodic conditions of infancy, and tropical sprue, since these diseases are due to a deficiency of calcium in the blood, and the parathyroids supply this calcium.

Other biochemical advances in the field of the endocrine system include the progress on the cure of goiter, without partial excision of the thyroid; the application of thyroxin, which has given rise to a thyrotherapy; and the preparation of an extract known as epinephrine (commonly called adrenalin), a hemostatic extract from the suprarenal glands of certain animals, usually sheep. The latter has been used with satisfactory results in raising blood pressure, curing or relieving acute bronchial asthma, and in a weak solution is found beneficial in conjunctivitis, iritis, and coryza.

Thus, in seven realms, chemistry has come to the aid of medicine to a striking degree in an immense variety of ways. In reviewing such startling advances, such awe-inspiring progress (all in the period of one or two generations) in these united sciences, is it any wonder they occupy the place in present-day culture that they now hold by the fulfilment of Pasteur's prophetic words—"The Sciences gain by mutual support?"

[7] *Scientific American*, Nov., **1925**, p. 310.

[8] Review of W. H. Grove and H. W. C. Vines' "Calcium Deficiencies: Their Treatment by Parathyroid," *J. Nervous and Mental Diseases*, **62**, No. 1, 61 (July, 1925).

CHEMISTRY AS AN INSTRUMENT OF GENERAL EDUCATION*

DOROTHY BAKER, THAYER ACADEMY, SOUTH BRAINTREE, MASSACHUSETTS

The classical and the scientific education were considered for many years to be farther apart than the antipodes themselves. Only recently people began to realize the possibility of combining satisfactorily these two fields of work. "The prime, direct aim of instruction is to enable a man to know himself and the world," wrote Matthew Arnold. To do this, it is necessary to cultivate every faculty, and the only solution of this problem is a liberal education.

DOROTHY BAKER

Most people realize the two-fold purpose of a liberal education, to discipline and develop the powers of the mind and to impart general information; but, although they can see the benefits of a classical education, they do not understand the value of a scientific education. In many ways studying mathematics produces the same results as studying chemistry, but unless one possesses that fairly rare characteristic of a "mathematical mind," higher mathematics almost inevitably becomes too abstract. Chemistry has proved itself an excellent substitute. Even for those who cannot discover great truths or comprehend higher problems, chemistry is of lively interest and great utility. Were it not extremely important in itself, it could prove its worth as an instrument of general education, as a means of developing eminently desirable qualities both mental and moral.

The most noticeable quality engendered by even a short study of chemistry is a valuable one. Methodical habits are visibly lacking in eight out of every ten people. The power of exact observation is something which all of us, at one time or another, long to possess. One person sees only half of that at which he looks. Another is led astray by confusing that which he sees with what he infers. Still another has but a

* Prize-winning high-school essay, 1926–27.

vague idea of the size or quantity of the objects in his line of vision. Chemistry, by its very nature, compels those who study it to be careful, accurate observers. At first, one is told the expected results of an experiment, but gradually one learns to note all the essential points without any guiding questions. Little by little, the student of chemistry builds up his powers of exact observation until the change in his vision is comparable to that in the vision of a person with poor eyesight when he puts on well-fitting glasses.

Besides quickening the clearness and accuracy of one's mental photography, a course in chemistry helps one to get an idea of relative values. The ability to observe well is almost worthless, unless one sees the big points big and the little points little. The systematic classification, so prominent in chemistry, trains one by force of example to apply the same method to life outside the laboratory. "Facts are stubborn things," Agassiz said, "until brought into connection with some general law." Every day one must face a confused jumble of facts and figures which must be sorted out according to their relative importance. In school books, in magazines, in newspapers, one continually comes upon new thoughts. Unless trained to distinguish between that which matters and that which does not, one finds one's self in possession of hundreds of miscellaneous, worse-than-useless facts.

The development of one's ideas of relative values leads easily to logical reasoning. Confucius once said, "When I have shown a pupil one corner of the subject, and he is unable to discover the other three, I do not repeat my lesson." Logical thought requires not only intelligence, but also thorough training and long practice. The multitudinous facts of chemistry cannot be retained merely by memorizing them. Without the aid of skillful reasoning powers, after even a short time, no one can possibly remember all the necessary details. Not only in the school room, but also in everyday life, does the need arise for such training. On being given a single important fact, one should be able to draw reasonable conclusions from this fact.

In some ways the ability to reason logically is dependent on a careful imagination. Wild guesses are quite useless in chemistry, since the scientific guess is little more than the result of a logical imagination. In chemistry, after taking a leap in the dark, one determines the place on which he is standing by the direction in which he started and the force with which he jumped. A classical education tends to cultivate an unrestrained, weak imagination. But such vague theories have no place in chemistry. To be sure, one is called upon to believe in such grand generalizations as well as such romantic vistas of minuteness that apparently only the wildest imagination could conjure them up. Notwithstanding the apparent impossibility of proving the soundness of

some of the theories, back of all the visionary speculations lies a conviction based on many facts and much thought.

Still, in spite of much thought, even the beginner finds that he must interpret his many facts cautiously. Nowhere is jumping at conclusions a more dangerous procedure. One learns to compare results over and over, to take into consideration every factor, to weigh the probabilities with the greatest care, and even then to reserve judgment. No hearsay or flimsy evidence is allowed since every result must be tested by the touchstone of fact. "The good white flour of scientific conclusion" comes from a mill that takes only the grist of verifiable fact. ("Discovery," p. 38, by Sir Richard Gregory, Macmillan Co., 1924.) Because even the novice at chemistry is both judge and witness, he must be unprejudiced. He realizes that apparent facts are not always true, and he does his best to try his data by all possible methods.

The chemist, endeavoring to check results in every way possible, oftentimes learns to devise new processes. His inventive faculty is both disciplined and excited; for the beginner, especially, is tied down by the need of remembering the purpose of his experiment, and is spurred on by the hope of doing away with error-producing conditions. The many ways of reaching the same result often foster a desire to attempt to simplify a process or to eliminate possibilities of error.

Besides encouraging originality, chemistry teaches its students to express themselves accurately. Even a sober, sensible person occasionally notices that he has acquired rhetorical habits that are almost alarming. Even when we observe accurately and realize the relative value of things, our speech is very likely to be so vague that we cannot transmit our knowledge to others. Not by memorizing formulas and definitions do we learn to do this, but by attempting to state briefly and clearly the results of an experiment or a given set of conditions. The indefinite or exaggerated habits of speech, into which all of us blunder sometimes, disappear of necessity when brought into contact with the clear-cut, lucid statements of chemistry.

But even among those who realize the value of the study of chemistry in cultivating methodical habits are many who overlook the unavoidable discipline afforded by chemistry.

More than almost any other science, it requires the strictest attention to detail. Even with the aid of logical reasoning, facts and more facts crowd the pages of every textbook on chemistry, until at first the neophyte feels himself bogged inextricably in their morass. Yet patient, systematic work cannot but have its reward. Frequently people with a little talent can gain high honors in an English course, with little or no studying, but in chemistry, although talent lightens the burden a little, even the best student must study hard and regularly. In this respect, chem-

istry seems a little fairer to the average student, who often grumbles at the seeming injustice entailed in other subjects. At any rate, the study of chemistry must needs develop, if only a little, that most desirable quality, patience.

Patience is indeed a requisite in the taking of the minute measurements in so many of the experiments of every course. In the hands of beginners, there is enough uncertainty in every experiment to keep awake interest, for success may depend on a seemingly most trifling detail. Again and again measurements must be taken to check and recheck the first results. Truly the training in patience is excellent.

Chemistry, like almost all sciences, is often criticized as being, at best, an uncertain subject, always liable to change. Those who study it realize that they must be patient in taking for granted some things which cannot be absolutely proved until man has learned more. Today students are obliged to be content with what they have, unless they have the divine gift that may enable them to overcome one more barrier blocking the march of progress.

But, for everyone who studies chemistry, it means the sacrifice of something or other. For some this is time. Even with a quick retentive memory, one must spend more time on chemistry to master it thoroughly than on almost any other study. Experiments often are long, and must be uninterrupted. In order to see clearly a few of the many sides of one subject, one must spend much time reading other references beside textbooks. He who clings to the form, doing only the exact amount of assigned work, does not gain the substance of chemistry, and in some respects might almost as well be doing nothing.

All who study chemistry find that it requires some patience and sacrifice. But since almost everything in life demands in some degree these two qualities, the real value of chemistry is not wholly dependent on them. However, there is nearly always implanted deep in the consciousness of every student, usually unknown even to himself, a sense of moral responsibility.

A classical education is often believed to make one too confident in one's self and one's powers. It is said that the way through the classics is a winding road along which one can see only a short distance at one time. At no time, however, can the study of chemistry be compared to this. It is a straight, level road leading to infinity. One can always see the great distance ahead, although it is impossible to comprehend it, or, because of the perspective, to estimate the size of the objects at any point. How can one be mentally arrogant while seeing this great vista? The most unbounded imagination seems trammeled. Although we have been progressing for hundreds of years, we seem scarcely to have left our starting place. Is it possible that one can study such a vast subject without feeling a great intellectual humility?

Yet many who think mental labor is perfectly honorable, even in this age of democracy, consider out of their class anyone who works with his hands. Chemistry certainly should rid them of this idea. Besides the fact that it is one of the best combinations of the two kinds of toil, in every textbook or scientific magazine there appear large numbers of men of wealth, rank, or genius who have done unremitting, hard physical work to give great scientific truths to the world. No matter how scornfully they were disdained by men, or how laborious and hopeless their task appeared, they stood firm, and as a result the world is wiser and better today. No one can have any contact whatsoever with their lives without coming to realize the dignity of work.

Besides preaching the gospel of the dignity of work, chemistry teaches a philosophical insight. One learns to see not merely facts, but their significance. Everything is a link in an endless chain. Science is often accused of destroying faith in religion, yet, although it cannot furnish a complete code of ethics, it shows that the lightest action will have its consequence to be felt at some future time. Morality simply for personal profit is of no benefit to mankind. But the scientist, subconsciously aware that cause and effect are inextricably linked together, does not "act lightly toward others or himself," unless he is a selfish charlatan. ("Discovery," p. 46, by Sir Richard Gregory, Macmillan Co., **1924.**) He walks in the light as God gives him to see the light. Whether or not he realizes it, he is influenced by his study, and is unwilling to do anything that would be detrimental to others. Unless he is very much given to introspection, he is entirely unconscious that he is considering his action in an altruistic light, but the relation of cause and effect has been so deeply rooted in him during his course of study that it is second nature to him.

In addition to being grounded in the law of Nature, being taught intellectual humility, and being given examples of the dignity of work, the student of chemistry develops one other most important trait. By force of example, it instills a regard for truth, and "no other key save the love of truth opens the chest of knowledge," wrote John Brown.

Now, as in all ages, it is indeed difficult to distinguish truth from counterfeit. Still, after one has himself tried carefully to prove statements, he finds that he is much more likely to see through superficial arguments and to attempt to reach the bedrock of truth, unmoved by the opinions of others and free from all dogma. It is not necessary, if one has no special talent in that direction, to devote a whole life to chemical research, but everyone will find that the reflection of truth's pillar of fire which guides and has guided great scientists, still rests on him to brighten his life.

Thus, even a single year of chemistry has lasting effects. It helps

to fill some of the gaps left by a purely classical education, not only by imparting useful information about the world, but also by developing desirable mental and moral qualities. Methodical habits pursued for a whole year surely leave their unmistakable impress on the mind, and with very little difficulty they may be carried over into other subjects, where they soon prove their usefulness. Vigorous discipline also teaches the great virtues of patience and sacrifice. The great, unforgettable lesson of moral responsibility, together with that of intellectual humility and the dignity of work, is planted so deeply that it can never be entirely uprooted. Last of all, chemistry kindles the flame of the love of truth, so that it burns with a clear light that can be extinguished only with difficulty. Because of all these facts, it is plain that no one can afford to neglect chemistry as an instrument of general education.

Sound Waves Impair Light Measurements. Sound waves from a motorcycle can hamper determination of whether the earth is drifting through the ether which is supposed to pervade all space, according to Dr. Dayton C. Miller of the Case School of Applied Science, who has been making a series of observations which may show the presence or absence of this ether. Two years ago, Dr. Miller repeated an experiment performed many years ago by Michelson and Morley. This was supposed to show that the earth was drifting through the ether, but an almost negligible effect was then obtained. One of the consequences of the efforts to explain the result was the Einstein theory of relativity.

However, when Dr. Miller repeated the experiment at the Mt. Wilson Observatory in California, he found that there was an appreciable effect. When he announced this before, it was hailed as proving that the earth was drifting through the ether and that it meant the downfall of the relativity theory. Other scientists since have tried the experiment without confirming Dr. Miller's results. Now he has set up the apparatus on the campus of the Case School and the first series of observations, which have just been completed, are completely in accordance with the Mt. Wilson results, he says.

As an illustration of the delicacy of the measurements, Dr. Miller says that one objection seemed to be that the traffic on two nearby streets affected the sensitive fringes of light and darkness which the instrument reveals. This was overcome with a heavy concrete foundation, but there were still disturbing effects. It was finally found that a trolley car going by had no effect, but if a motorcycle started noisily two blocks away, the fringes completely vanished. This proved to be due to the sound waves from the machine causing a variation in density of the air through which the light had to pass, and so prevented the appearance of the alternate bands of light and dark.—*Science Service*

THE RELATION OF CHEMISTRY TO AGRICULTURE*

JOHN LIVAK, RUTLAND HIGH SCHOOL, RUTLAND, VERMONT

"At the head of all the sciences and arts, at the head of civilization and progress, stands, not militarism, the science that kills, not commerce, the art that accumulates, but agriculture, the mother of all industry, and the maintainer of human life."[1] Agricultural chemistry offers the fundamental scientific basis upon which to build a sound and permanent agriculture, therefore, it should be of vital interest to every American.

JOHN LIVAK

For the last three hundred years, the American people have been living on the virgin lands of the United States. It has been only within recent decades, when all the best unoccupied agricultural areas have been staked out in homesteads, that the question of maintaining and improving soil fertility has begun to receive serious consideration. The farmer must develop intensive methods of agriculture and increase the productivity of his fields, in order to feed and clothe our rapidly increasing population.

Plants are made of soil material and air material. Of the nintey-two elements that comprise the earth, only thirteen (hydrogen, oxygen, nitrogen, chlorine, potassium, magnesium, calcium, iron, sodium, carbon, sulfur, phosphorus, and silicon) are essential to plant life. Three of these, hydrogen, oxygen, and carbon, are obtained from the air and water. The ten others, in the form of salts, are dissolved in the water, which the plant obtains, by osmosis. In the case of all but three of these elements, the amount deposited in the soil is sufficient to supply the demands of the plant.

The three deficient elements are nitrogen, phosphorus, and potassium. Consequently, man must supply these to depleted soils, if he wishes

* Prize-winning high-school essay, 1926–27.

[1] James A. Garfield.

plants to grow. When we realize that a bale of cotton (500 pounds) deprives the soil of 84 pounds of nitrogen, 15 pounds of phosphorus, and 41 pounds of potassium, we can easily comprehend why the soil loses fertility so quickly if no plant food is put back. Further, when we know that these elements are fatal or useless to plant life in the elemental form, but, that fixed in a compound they are available as plant food, we begin to understand the difficult problem that man must solve. Chemists, as early as 1840, began research on this problem. It was the German chemist, Justus von Liebig, who first discovered that soil fertility could be maintained by the application of chemicals. This important discovery led to our modern commercial fertilizers.

The world's principal source of nitrogenous material in the past has been the nitrate beds of Chile. While these deposits are enormous, they are exhaustible; hence, the chemist, believing in being prepared, has resorted to artificial sources for the production of soluble nitrogen compounds. He has been so successful that, at the present day, the synthetic air-nitrogen products supply most nitrogen to agriculture; by-product ammonium sulfate comes second; and Chilean nitrate falls into third place. The chief source of ammonium sulfate is coal; ammonia being a by-product when coal is burned to produce coke. About 80,000 tons of available nitrogen were produced in 1917 by this method. There are several methods for the fixation of atmospheric nitrogen. In the United States, the most successful one, commercially, is the combining of nitrogen with calcium carbide at the temperature of the electric furnace to form cyanamide. (The Muscle Shoals Plant was designed to produce 110,000 tons of ammonium nitrate, annually.)

By far the greatest quantity of phosphoric acid used in fertilizers is derived from the mineral phosphates, the chief source of which is the United States. Besides supplying our own needs, we export $7,000,000 worth to Europe annually. At present, the pebbles dredged up from the bottom of Florida lakes and ponds are the chief source, but the supply is limited. There is no need to worry, however, for deposits in the states of Idaho, Wyoming, Utah, and Montana have been estimated to contain more than 6,000,000,000 tons of high-grade rock, besides many times this amount of lower grade phosphates.

Germany and France, at present, have the natural monopoly of potash. The United States had to depend on this source, until the chemist developed artificial methods of producing potash. His task was not as easy as it may appear to the casual observer, for, although, potash compounds are as cheap as dirt, every handful of gravel containing 10 per cent potash has it in combination with silica, from which it cannot be easily separated. In 1924, through the aid of chemistry, the United States produced 44,000 tons of potash salts. The sources were natural brines, dust from cement

mills, dust from blast furnaces, alunite, kelp, molasses residue from distilleries, and waste liquors from beet-sugar refineries. Recent governmental investigations have resulted in the improvement of methods of recovering potash from the mineral, greensand, deposits of which cover large areas in the states of New Jersey, Delaware, and Maryland. Further discoveries in the state of Texas have strengthened the belief that commercial deposits of potash underlie considerable areas in this region and only await comprehensive surveys with core drilling to be accurately located. Taken as a whole, an independent supply of American potash in the future seems a probability.

The chemist, having obtained inexhaustible supplies of plant food, next directs his attention to the welfare of the plants. Plants, like human beings, are subject to disease, and their illnesses must be diagnosed, if we wish a plentiful supply of food. Sometimes, microscopic organisms, which cause diseases like anthracnose, rust, smut, and, sometimes, visible and familiar insects like the boll-weevil, corn borer, and Colorado beetle eat away the living cells of the plant. The losses to American agriculture from the depredations of the cotton boll-weevil alone exceed $300,000,000 a year. One of the most successful means of combating this pest has been by means of calcium arsenate, which is now applied by airplanes. The chemist, besides first applying insecticides and fungicides, has done much to make them more effective and less costly. He has pointed out that if calcium arsenate is caused to assume a positive charge of electricity, it is attracted to the leaf, which is negatively charged. Experiments have shown the adhesiveness of positively charged calcium arsenate to be 200 times greater than that of the standard product. Another chemical success, too recent to be adopted industrially, is the extraction of a substance, trimethylamine, from the cotton plant, which attracts the boll-weevil and lures the insect to its own destruction. Thus, by instituting chemical warfare against plant pests, the chemist has lowered cost of production for which we, the consumers, should be thankful.

The agricultural chemist, having nourished and doctored the plants, again appears on the scene when the crops are harvested. This time he employs his creative genius, and, through the medium of by-products, he has utilized surplus products, as well as produce of inferior quality, in some cases doubling the value of the crop. An effective example is shown in the case of corn. In 1925, 3,013,000,000 bushels of corn were raised in the United States. Of this amount, 50,000,000 bushels were worked up by the factories into 800,000,000 pounds of corn sirup; 600,000,000 pounds of starch; 230,000,000 pounds of corn sugar; 625,000,000 pounds of gluten feed; 90,000,000 pounds of oil, and 90,000,000 pounds of oil cake.

A kernel of corn is composed of three parts, the germ, the body, and

the hull, each of which breaks up into hundreds of useful products. The germ produces corn oil which, in turn, becomes table oil, dyers' oil, soap, glycerine, or rubber substitute, just as the wizard chemist decrees. The germ produces, also, oil-cake and oil meal, which are utilized as cattle food. The body breaks up into starch, dextrose, glucose, corn sirup, hydrol, tanners' sugar, cerelose, white, canary, envelop, and foundry dextrin, British gum, amidex, and gluten. The gluten subdivides into vegetable glue, vegetable casein, and gluten meal. The hull is utilized in the form of bran. Having thus utilized the kernel, the chemist, ever economical, has turned the cob (2,000,000 bushels of which were thrown away annually) into a gum, suitable for bill-posting and, also, into a varnish.

The chemist, always thrifty, has utilized cull oranges, grape-fruit, and lemons, and has profitably converted them into citric acid, marmalade, candied peel, lemon oil, pectin and cattle feed. Further, he has found a use for apple pulp in the manufacture of pectin; and, after the pectin is extracted, he has economized still more, by pointing out that the pomace made suitable cattle food.

For another example of chemical utilization, let us consider cotton. Cotton has been known to the West since the time of Alexander the Great, but the attention of mankind has been focused so long upon the valuable fibers or seed hairs of the cotton plant, that chemists overlooked, for many centuries, other numerous possibilities of utilization. It is only since the Civil War that the possibilities of the cotton seed, which was either thrown away or burned as fuel, were realized. Nevertheless, the chemist has made up for lost time, for, in 1925, he added $200,000,000 to the value of the cotton crop by converting the cottonseed into articles of commerce.

In this short discussion, it would be impossible to name the countless useful things that a ton of these seeds produce. But when we know that from the linters come such articles as felt, rope, carpets, smokeless powder, varnishes, celluloid, and artificial silk; from the hulls, fertilizer, cellulose, fuel, and feed; from the meats, soap, flour, cosmetics, oleomargarin, artificial leather, candle pitch, and glycerin, we begin to realize the creative genius of the chemist.

The extent of agricultural chemistry is so vast that even here the chemist did not stop. Ever on the outlook for more economical methods of production, he has discovered substitutes for overworked plants. For instance, rubber is as essential to agricultural production and marketing of crops at the present time as it is to urban industries, but, it is expensive. The chemist sought a substitute for the juice of the rubber tree. He discovered that vulcanized corn oil, mixed with pure rubber, gave the latter greater durability and elasticity, besides lessening the cost. Iso-

prene, an oily, volatile, hydrocarbon (C_5H_8) obtained by the distillation of caoutchouc, is another successful substitute, scientifically, though not industrially. Recent research has also resulted in obtaining a quality of rubber from the African euphrobia tree, which is comparable with that of para. This discovery is too modern to be put into practical use. At present, the chief source of rubber substitute is the Mexican plant, guayale, which is not cultivated extensively to eke out our supply of natural rubber.

In 1870, governmental chemists introduced a new plant, the navel orange, into the United States. The new industry proved so successful that there is now an average annual production of 8,600,000 boxes of oranges and 3,000,000 pounds of orange by-products. Thus was obtained a plentiful supply of the popular and healthful fruit.

Another example of the chemist's power is discovered in the production of sugar-beets. Although reference to the sugar-beet is made in ancient Babylonian catalogs of plants as early as 710 B.C.; it was not until 1747, that a German chemist, Andrew Marggraf, made the important discovery that sugar of identically the same properties as that obtained from the sugar cane could be extracted from the beet. The industrial utilization of this discovery broke England's monopoly of the sugar industry which she had acquired through the West Indies.

Another important phase of agricultural chemistry, which could be mentioned, is that referring to law enforcement. From time immemorial, articles and products of utility have been subject to adulteration, misbranding, or other forms of deception, practised by unscrupulous persons. In modern times, the chemist plays a most useful and essential rôle in detecting adulteration of fertilizers, cattle-feeds, insecticides, fungicides, and other agricultural necessities. Through his influence, efficient State and Federal laws have been passed, which require the accurate labeling of such products as to their chemical composition, thus protecting the farmer against deception. The chemist protects the consumer of agricultural products in like manner, for the milk, butter, grain, fruit, sirup, and other products, which the farmer sells must come up to a certain standard of excellence, if he does not wish to be penalized by some one of the laws against adulteration.

Nearly half a century ago, a fertilizer, selling at $32 a ton, was put on the market. The fertilizer contained mud dug from under the waters of a harbor. Someone ventured to doubt the efficacy of the trace of ocean salts in the mud as a stimulant for crops. The skepticism spread, and, finally, resulted in the chemical analysis of the mud fertilizer. The analysis unearthed the fact that the stuff was worth $1.02 a ton as a filler, but was useless for other purposes.

Much fraud is perpetrated upon the consumer through the sale of adulterated insecticides, sold under misleading trade names, the cost

of the products being far above the value of the constituent ingredients. A product of this kind was offered for sale a number of years ago. The manufacturers claimed that it was not only of great value and efficiency as an insecticide and fungicide, but was also useful as a plant food. Chemical tests showed a total of only 0.07 per cent of plant food, while, as an insecticide, it was practically worthless.

It seems almost inevitable that every new valuable discovery in agricultural chemistry should immediately be put into an illegal use. The value of commercial pectin was no sooner discovered than a host of fraudulent manufacturers began to use it as an adulterant in fruit jellies. Ethylene gas, used to impart a yellow color to mature citrus fruits of a green color, was immediately misapplied by unscrupulous producers to give immature oranges, lemons, and grapefruit a false appearance of ripeness. Hundreds of examples of this nature could be cited and the chemist must be ever on the alert in order to protect the consumer from deception.

Thus, in five ways; namely, by feeding the soil, being plant doctor, creating by-products, finding substitutes when necessary and acting as detective, the chemist has been of great value to the farmer, and through him, to us, for as Theodore Roosevelt truly states, "The strengthening of country life is the strengthening of the nation."

Chemistry is the basis which underlies the existence of soils and crops and animals. The remarkable achievements of the agricultural chemist in the past bear witness to this. Yet, the chemist, working alone, cannot predict a successful future. Let us, as a nation, coöperate with him, and thus show him our appreciation of the enriching science of chemistry, which utilizes Nature's products to the utmost.

I wish to acknowledge the valuable aid rendered me in the writing of this essay by the volume, "Chemistry in Agriculture," Edwin E. Slosson's book, "Creative Chemistry," and the United States Department of Agriculture.

New Fertilizers Have Pleasing Fragrance. Farmers and gardeners will welcome the news that recent U. S. Bureau of Soils tests have found in certain common commercial by-products, excellent fertilizers of unoffending odor. The farmer of the future who uses cocoa meal as a fertilizer may well rejoice for from his fields the winds will waft a pleasing fragrance like a freshly opened can of breakfast cocoa. At present this by-product of cocoa and chocolate manufacture is little used as a fertilizer, but it may be produced cheaply in great quantities and soon may be extremely useful. Some 20,000 tons of by-product cocoa cake, from which the meal is ground, are made annually in the United States. It resembles breakfast cocoa but is of lower grade, with less fat content, and is made by the pressing of roasted and shelled cacao beans. Other by-products of the cocoa industry that show fertilizer possibilities are cocoa meal shell and presscake, or defatted cocoa. Cocoa cake contains 4 per cent nitrogen, shells about 3 per cent, and presscake, 4 per cent. Other new fertilizers, dried crab waste, shrimp waste, and shrimp bran, have a distinct fishy smell, somewhat like that of the common commercial varieties. After drying they are richer in plant food elements than cocoa by-products.—*Science Service*

THE RELATION OF CHEMISTRY TO THE HOME*

ENOS ABERNATHY, HINDS COUNTY AGRICULTURAL HIGH SCHOOL, RAYMOND, MISSISSIPPI

The science of chemistry wields an influence upon our everyday lives which is but little realized by the average person. Day after day we continue to use the manifold comforts and conveniences with which chemistry has supplied us, rarely thinking of all the toil and hardships that were necessary before they came into existence. The Chemist, that personality to whom is known the vast secrets of Nature, bending over his crucible and retorts and the other chemical implements of his laboratory, has brought forth astonishing substances from seemingly useless and valueless materials. He has created vast industries which have developed the natural resources of our nation; he has furnished our War Department with munitions to provide for the national defense; he has supplied our farmers with fertilizers to grow the crops which feed the country; he has given to our physicians and surgeons the necessary materials with which to prevent disease and to fight death; but, chief of all, he has given to our homes and to our home lives all the blessings of wholesome and comfortable living.

ENOS ABERNATHY

In its relation to the home the influence of chemistry is universally felt. Wherever we turn and whatever we use, chemistry directly or indirectly affects us. Volumes can be written on the various phases of this relationship; but in a short treatise like this, only a few of the more important points can be mentioned.

In the soap industry the chemist has played an important part more than elsewhere in the development of our homes. The extent of the use of soap as a factor for cleanliness has become so great that we little realize what an important part it plays in our modern civilization, and for how short a time it has been used in any considerable amount. As

* Prize-winning high-school essay, 1926–27.

man rose from the stages of savagery and barbarism, he learned to recognize the importance of cleanliness. He, struggling for some means whereby he could remove dirt, discovered that a mixture of grease and wetted wood ashes accomplished this feat. This crude method of making "soap," until recent years, has been largely a household art; therefore the result was that real, comfortable cleanliness was a luxury which could be purchased only by the rich. Then the chemist came to the rescue. He saw the need for the production of soap on a uniform and extensive scale. He took sodium chloride and water and produced caustic soda, which he mixed in definite proportions with fats and oils, and created for the home the bar of soap.

But the chemist did not stop here. As the demand for greater cleanliness in the home grew, he created various cleansing substances that have their particular uses. The caustic soda which is used in the manufacture of soap we employ under the name of lye to clean drain pipes and floors that are badly caked with dirt and grease. Soap powders and washing sodas are used to a great extent for all kinds of rough work. Through his knowledge of solutions the chemist has given us means whereby we may remove almost any stain that mars the appearance of clothing, woodwork, or in fact everything that exists in the home. It can be truthfully said that the chemist has made our homes clean.

Yet, even more important than his contribution to cleanliness in the home is the development of newer and better theories of nutrition and newer and more healthful ways of preparing our foods. Many old, inconvenient, and unsanitary methods of dealing with our food supplies have been discarded, and newer, more scientific methods have taken their places. A typical example of these improvements is in the proper handling and pasteurization of milk. By these processes the spread of contagious disease germs has been eliminated to a certain extent in cities and towns where adequate chemical control is not provided. Pasteur, the great chemist, has made millions of homes bright and happy by his discovery that milk, the primary food of the child, can be safeguarded from contamination by the process named after him. Chemistry personified in this great scientist has made real a familiar picture: there is a child drinking milk from a bottle held in the hands of its mother, who is confident, as she watches her child, that there are no disease germs contained in the milk.

The proper preservation of all food products, including meats, vegetables, and fruits, thus enabling us to have a varied diet at all times of the year, is another triumph for chemistry in its relation to the home. In a country like ours, when the seat of production is very often far removed from the place of consumption, the need for preserving the many perishable food products for use during the year has been very great.

How to overcome the tendency for meats, vegetables, and fruits to decay was the problem that faced the chemist. He solved this problem and, as a result, today we can procure in a grocery store practically any food product in containers that keep it as fresh as when it was placed therein. This preservation of food has proved a blessing to everyone. The laborer that takes his lunch with him most likely has canned milk and ready-cooked, canned meat for his noon meal. The housewife need no longer spend the greater part of the day over her kitchen stove. Canned beets, tomatoes, meats, asparagus, soups, and other products seem to eliminate her labor to a great extent, and the ready supply of all kinds of canned fruits furnishes her with the choicest of desserts at a minimum cost.

Along with the preservation of food comes the development of bread-making to such a point that baker's bread is generally conceded more sanitary and convenient than the old home-made bread. The relation of the chemist to this development may not be so noticeable, but nevertheless it does exist. He has taught the bakers the proper uniform method for making their product. He also acts as supervisor and inspector, and sees to it that the bread which we eat is wholesome and free from adulterations. In home baking the chemist has been equally busy. He has invented baking powder to supplant the more inconvenient method of raising dough by the use of yeast. In the home when the "quick breads" such as biscuits, pastries, and cakes are to be made, to leaven by the use of yeast takes too long as the amount of gas that escapes is uncertain. In the discovery of baking powder, a distinct chemical product, the chemist has given us the means for quick leavening action combined with greater uniformity in results. Again the chemist has added convenience and expediency to the home.

One of the most outstanding achievements of chemistry in its relation to the home, is in the securing of good, convenient cooking fats by the hydrogenation of oils. This process has made it possible to start with an oil that is entirely liquid at ordinary temperatures and make of it a brittle mass as hard as the hardest of candle stearin, or to stop the process at any stage and get a fat of any consistency desired. The housewife, who had to use lard, which was not acceptable to some people on account of digestive disturbances, or a liquid fat that was inconvenient to handle, is now supplied by the chemist with desirable semi-solid cooking fats artificially made that are better in many respects than the natural products.

Yet, more important than all of these contributions of chemistry to the food problem of the home, is the formulation of theories of nutrition, which have now become knowledge and which enable us to prepare a balanced diet from which the maximum nutritive value may be obtained.

The struggle to discover all the factors necessary for the proper function-

ing of the human body has been a long and difficult one, and it is only at a recent date that we have learned the true relation of the various foods to our body The fundamental elements in nutrition have been formulated in explicit, scientific, and practical terms. We know now how to use our food supplies to the best advantage in order that all people may be as well nourished as possible. We know likewise that good nutrition is a very important factor in the health and happiness of our home life.

Chemistry, aside from its relation to food and cleanliness, has created for our homes numberless articles which we use and enjoy without thinking that they were made through chemical processes. Artificial silk, manufactured from cotton fiber, and mercerized cotton, prepared from cotton cloth, have given us materials that are more economical than the genuine product, but that serve the same practical purpose. We can purchase for thirty cents an artificial silk tie that looks as well as a silk tie costing a dollar and that will wear long enough for the wearer to tire of it. Even net and lace, formerly made by laborious and drudging processes of manual labor, can now be manufactured by machinery. This advance is made possible only by the discovery of a solvent for cellulose by the chemist. Artificial rubber has been prepared by chemical means. Leather, once obtained only from the hides of animals, can now be manufactured from cotton, ether, and alcohol, so that a vegetarian can with convenience buy shoes that do not contain a trace of material from living matter. The oil cloth found in so many homes is made chemically from canvas and linseed oil, while the linoleum that so many people tread upon is manufactured from ground cork and linseed oil. Canvas, coated or impregnated with soluble cellulose, furnishes us with new fabrics that are better, cheaper, and more abundant than leather, which they have replaced in many instances. What valuable and useful substances the chemist has made from mere cotton-waste, rags, paper, and even wood pulp!

It has been but a few years ago since almost all dyes were extracted from plants and trees; besides being dull they were comparatively rare and expensive. Chemistry, however, brought about a radical change in existing conditions. Over sixty-nine years ago a chemist by the name of W. H. Perkin prepared the first dye from coal. The preparation of others soon followed, until today thousands of these dyes of every shade and color are manufactured. These aniline or coal-tar dyes have almost supplanted the old vegetable dyes. The coloring of clothing and materials has become a much less expensive process.

The cooking utensils, stoves, and ranges undergo chemical operations before they are placed in our possession. The cooking range is made in the blast furnaces of Pittsburgh from the iron rust of the Lake Superior region. The aluminum kettle is made from aluminum oxide, by decom-

posing the aluminum oxide in the molten cryolite. The glass tumbler is made from sand, sal-soda, and quicklime, while the porcelain dish is manufactured in kilns from kaolin, feldspar rock, and plastic clay covered with a fusible glass glaze.

The charcoal that is used to set fire to the coal is made from wood by heating it in the absence of air, while the paper that sets fire to the charcoal is made chemically from wood-pulp or rags. The very match that first starts the combustion in a chemical reaction is made from bones, sulfur, and fish-glue. The home is full of such valuable furnishings that owe their existence directly to the chemist.

The same relationship between chemistry and the home exists in the improved methods of heating and lighting that have been developed by chemists in conjunction with engineers. The production of heat and light are in themselves chemical reactions, and the chemist's knowledge of combustion and the light ray has added a great deal to the development of these two important factors of our home-life. The carbon filaments for incandescent lamps are chemically made from zinc chloride and cellulose, while the electric bulb itself, from which the air formerly had to be expelled, is now filled with a gas that is prepared by the chemist. The introduction of the new oil heating system within the home is also due in the first place to the chemist, who has taught the engineers to construct these systems in such a manner as to bring about complete combustion of the oil, thus eliminating the possibility of unhealthy and uncomfortable odors escaping.

Finally, the improvement in all materials entering into the actual building of our present-day homes is directly due to the chemist. His knowledge of the chemical actions that take place when mortar, cement, and concrete harden, and his knowledge of properties of the various steels and other metals have brought about the present durability and beauty of home architecture. Our buildings are now constructed so that they form one massive, indivisible structure rather than a pile of a great number of stones, one on top of the other, as was the case in the old Roman homes. Our cottages have also been made more durable through the use of the various paints that prevent oxidation and thus remove the tendency of the wood to decay. The new plumbing and toilet fixtures are likewise the chemists' handiwork. In fact, almost everything that pertains to the actual building of our homes is made or personally supervised by the chemist.

Thus we see, with only a hasty glance at a few of the factors which pertain to the home, that the science of chemistry has extended a great influence upon our family life. This influence continues to be felt. Discoveries made daily by chemists all over the world, however imperceptible, are working toward a change of existing conditions. The chemist has

opened and disclosed to us many of the secrets of nature; yet his work is but begun. In this scientific age in which we live nothing seems impossible and we know not what important truths may be revealed tomorrow. We know that in the past the relation of chemistry to the home has been very great to our food supplies and to the furnishings that we find therein. We may truly say that the science of chemistry is the mother of all other sciences, because of the influence which it has upon the entire world. We may look forward to the future for it to continue to add comforts and blessings to our lives.

Bibliography

"Chemistry in Agriculture," edited by Joseph S. Chamberlain. (New York: The Chemical Foundation, Inc., **1926.**)

"What Price Progress," Hugh Farrell. (New York and London: G. P. Putnam's Sons, **1926.**)

"Chemistry in Industry," edited by H. E. Howe, Volumes I and II. (New York: The Century Company, **1923.**)

"The Future Independence and Progress of American Medicine in the Age of Chemistry," The Chemical Foundation, Inc. (New York City: The Chemical Foundation, Inc., **1923.**)

Ultra-Violet Rays Save Costly Animals in Zoo. How ultra-violet radiation, used on sick humans, saved the lives of five valuable and desperately ill animals in the New York Zoölogical Park, is told by Dr. Charles V. Noback of the Department of Comparative Medicine.

His furry patients consisted of a red howling monkey, a grivet monkey, and three lemurs, which are small animals belonging to the same order as monkeys but lower in the evolutionary scale. They are all expensive animals and their threatened death from "cage paralysis," which is a disease very similar to rickets in human beings, was regarded by the zoo authorities as a genuine impending calamity. When they had reached a state in which they refused all food and could hardly move, Dr. Noback was called in.

The helplessness of the animals at the outset simplified the treatment. Dr. Noback simply placed his quartz-tube mercury vapor lamp behind their bowed and immobile backs and turned on the current, without needing to tie or constrain them in any way.

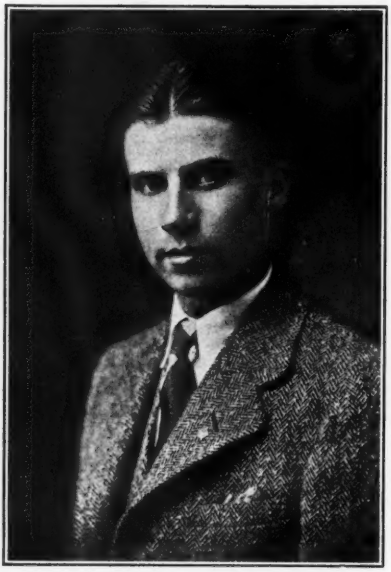
The treatment was kept up for a month in the case of the red howling monkey, and from three to four weeks with the others. In all cases the stiffness and decrepitude that marks the disease in its extreme stages soon disappeared, the eyes became bright again, the hair glossy, and the patients displayed a manifest renewal of their interest in food.

Dr. Noback notes that the doses of the rays to which he subjected the hair-covered skins of his animals were much more intense than those intended for the bare skin of a human being. For this reason he had to be careful about hairless and non-pigmented areas, such as the region around the eyes, to avoid producing severe sunburn.—*Science Service*

THE RELATION OF CHEMISTRY TO NATIONAL DEFENSE*

DUDLEY L. HARLEY, THE MERCERSBURG ACADEMY, MERCERSBURG, PENNSYLVANIA

There is a certain fatalism in the evolution of this world. It is expressed in the progression, the gradual building up, the metamorphosis of our ideas, our codes, our arts and sciences, our industries and institutions. They do not all move apace, these elements. Frequently one will lag behind the procession and become apparently static for a long period, and occasionally parts will seem to disappear entirely. But eventually they advance. From time to time there is brought to bear some enlivening agent, an energizing, invigorating force, which purges of anachronisms the backward element, and stimulates and quickens it to new developments along new lines. We cannot check these developments, no matter how undesirable their probable outcomes may seem to us. Modify their effects and exert a certain control over their courses we sometimes may, by careful study of their causes, but retard them we hardly can. They are inevitable.



DUDLEY L. HARLEY

The Present State of Warfare

Something of this nature has recently happened to the ancient institution of warfare through the stimulating influence of science, and particularly of chemistry. It is being revolutionized to an unheard-of degree, and we do not know yet just what to make of the transformation.

Perhaps, considering the wide scope and degree of the change, the relatively short time in which it has occurred, and particularly human nature in its reaction to the new, the sensational, the confusion of opinion and lack of proper evaluation are but to be expected. The alteration has been too extensive, too recent for us to grasp its true import.

Consider, for example, a single field—one in which the influence of the chemist was first felt, and to which the public mind at once turns to asso-

* Prize-winning high-school essay, 1926–27.

ciate chemistry with warfare—that of explosives—and observe what changes have been wrought. The art of explosive-making was largely chemical in its inception; it is more so now than ever. Some six centuries ago, the introduction of gunpowder effected a complete reformation of the established practices of warfare. To-day, explosives still hold the position of the most important single weapon, but they are vastly different substances from those in use a century ago. The feeble gunpowder that yesterday threw a cannon-ball a few hundred yards is replaced by some powerful compound which hurls several hundred pounds of steel seventy-five miles to burst it into flying fragments. The terrific crushing force of bombs that can split a huge battleship from stem to stern was unknown in the days of '64. What force has been acting to produce these innovations? The vitalizing agency of chemistry is once more at work, and has pushed development at a rate which already challenges our credulity. From such unpromising materials as coal and cotton, from the waste heaps and refuse piles of the nation's industries, the chemist has constructed a series of remarkable explosives suitable for every purpose: cordite, gun-cotton, nitro-glycerine, T.N.T., and a host of others whose amazing potency spells the doom of fixed fortifications, and marks the beginning of a new epoch in defensive preparations. From the very air he has plucked them, when the materials he wanted were not at hand. And the end is not yet. Small wonder, then, that the mere mention of his name is sufficient to conjure up fantastic predictions and awed conjectures. His are achievements to inspire no small degree of respect.

Chemistry's Most Valued Contribution

When, however, we turn to the latest and most spectacular of chemistry's contributions to warfare, even these feats are somewhat overshadowed. It may be that we are approaching the limit in explosives, that increased power would be unsafe with our present facilities for utilizing it. But in gas warfare we have an instrument the possibilities of which have barely begun to unfold. Here is something that transcends mere improvement. Here we have the creative chemist at his work, a work which has given us an entirely new weapon, easily the most effective, the most efficient, and, if we may believe statistics, the most humane, devised since the days of Cain. One cannot hide from a gas. There is no security behind tree or rock or a dugout. And once it finds its victim, the bombardment of the molecules is far more sure than that of the shells. A weapon that, although just introduced, was responsible for one-third of all casualties in the last war; that killed only four out of every two hundred men it disabled, allowing all but one of those remaining to return to perfect health; that permanently crippled no one; and that, in addition, observations would indicate, acts as a preventive against tuberculosis,

approaches as nearly as possible the ideal weapon—one that incapacitates temporarily the greatest number of men, while permanently injuring the least.

Importance of Gas

The science of gas warfare is susceptible of amazing development. In the next war it will contend hotly with explosives for the place of first importance. It is the task of our chemists to keep closely in touch with, to lead if possible, this advance, that when we stand in need of defense, the nation may not be lacking in a department destined to play so important a rôle in modern warfare.

The Chemistry of Our Food Supply

There are other things less obviously relevant to the science of battle, yet which are fundamentally essential to national safety. One of these, on which can be found the characteristic stamp of chemical guidance, is the maintenance of an adequate food supply. Not only soldiers, but also the folk back home must be fed, and wars starve land as well as people. For a long time we of the United States have been using lavishly the natural fertility of our fields, but we are being increasingly brought to the realization that what we take out of the land in crops, we must put back in other forms. There are three main fertilizers necessary to the proper culture of the soil: phosphate, potash, and nitrate. Phosphate we have abundantly in the large deposits of the South, but its conversion into the market product must be carefully planned and regulated by the chemist. Potash, we were content to buy of what Germany was willing to sell us, until the war put a stop to that. Such unsuspected sources as, under the stimulus of necessity, were then uncovered, though meager enough, must be placed to the credit of the industrial chemist.

As typical evidence of the benefits of chemistry to the fertilizer industry, we have only to turn to our nitrate supply. Nitrates, in addition to their value as fertilizers, have an extensive use as the basis of all explosives, and any country engaged in warfare must have them in great quantities. At first thought this would not seem difficult; above every seven acres of ground may be found as much nitrogen as the world consumes annually in its principal commercial form. But nitrogen in the free state is useless, and being an extremely unsociable element it can be enticed into combination only with great difficulty. Hence, in common with the rest of the world, we have gone to the great deposits of Chile for our supply. In time of war it was next to impossible to maintain connection with this source, and as a last resort, the chemist was called in to tackle the problem. He found that oxygen and nitrogen from the

air, when passed through an electric arc, can be combined; also that under the influence of certain catalysts—those marvelous and mysterious enigmas of chemistry whose mere presence is enough to incite inexplicable reactions —nitrogen will join with other elements in the fixed, or useful state. By these, and other products of his research, we are now assured of a sufficient supply of nitrate from an inexhaustible source.

The Chemist's Salvage in the Coke Industry

Another source of nitrate has been found in the coke ovens of the country. Not so long ago, practically all coal-coking was carried on in the old fashioned bee-hive ovens; which, though producing a good quality coke, sent up in flames everything but the carbon. Thereby was wasted no inconsiderable part of the whole, containing compounds of great potential value, among them ammonia, a compound of nitrogen with hydrogen. The chemist, being the natural enemy of waste, undertook to point out to the coke producers the error of their way, with the result that we now recover about half of these squandered resources, and in consequence enrich ourselves annually to the extent of some 300,000 tons of nitrate, along with numerous other materials of high value in the manufacture of explosives, gases, medicines, and to the other departments of warfare. So indispensable have the by-products of this industry become, that our security in time of national peril may well pivot upon their proper development and application.

Chemistry's Effects in Metallurgy

Some of the most astonishing and fascinating, though less spectacular, and consequently less widely appreciated, results of the application of chemistry to industries of wartime importance, are to be found in the province of metallurgy. We regard with wonder the construction of huge cannon; we read with amazement of the quantity of shells spent in a single bombardment; we marvel at the rapid advance in naval-craft design. We stand in awe of these creations of the mechanical engineer; but if we look closely, we almost invariably discover behind them, as the primary motivating principle, the hand of the chemist. We find that without his highly resistant metals to withstand the terrific force of the explosion and the intense corrosive action of the hot gases liberated on their interiors, the impressive cannon would be unknown; that but for high-speed cutting tools made of his alloys of steel with chromium, vanadium, or tungsten, which, operating at white heat, cut away a ton of steel an hour, we could turn out in wartime only one-fifth the amount of shells that we do; that lacking similar alloys, the armor plates of our battle-ships, unpierceable except by shells of like material, would be non-existent, and the tank, motor-truck, submarine, and scores of other mechanical contrivances would be far from their present form.

Products of the Electric Furnace

By means of that Aladdin's lamp of industry, the electric furnace, carbon and silicon are fused into carborundum—an abrasive that has revolutionized shop practice. With the aid of its tremendous temperatures, calcium carbide, without which there would be no oxy-acetylene torch, is produced; and it is gradually replacing other processes in the manufacture of steel. Superiority in the field of metallurgy cannot be too strongly urged; many a battle has been lost or won by a slight difference in this respect.

Progress in Aircraft Design under the Stimulus of Chemistry

Gases, aside no class of instruments, perhaps, are destined to play a more active part in future warfare than aircraft. Their inherent quality of annihilating space, so in keeping with our present lines of large scale operations, together with the steady improvement which they are undergoing, marks their increasing use as inevitable.

The impetus to the aircraft industry since the war can be traced directly to the analysis of its problems from a chemical standpoint. In discovering the electrolytic process for the cheap production of aluminum, and in blending this aluminum with copper, magnesium, and other metals, to produce a series of remarkable alloys having the strength of steel with but one-third its weight, the chemist has reduced the weight per horsepower of the airplane motor from 117 to 1.75 pounds. With his special steel alloys to strengthen delicate parts, and his improved shop methods, he has produced a lighter, a more powerful and in all respects a more efficient engine, capable of withstanding operation at full throttle for not just 50, as formerly, but for over 300 hours. Without such refinements of structure and design, our all-metal airplanes and giant dirigibles would be too cumbrous to rise above the ground.

The difficulty of inflating lighter-than-air craft has been overcome in two ways: by a convenient process for generating hydrogen gas in large quantities on the field, and by the introduction of the non-inflammable helium. The discovery of this last in the sun, its identification on the earth, its separation and refining in usable quantities, is one of the brightest romances of modern chemistry.

All the wear-resisting paints and varnishes, shrinking solutions or "dopes," tough, impermeable fabrics, tenacious glues, and the host of other articles which enter into the finished product, are subject either to chemical control or chemical manufacture, while the development of anti-knock fuels, making possible high-compression engines, and the perfection of lubricants capable of withstanding the strain of these engines, are in themselves real chemical problems.

The Chemist as a Healer

From the foregoing one should not receive the impression that the chemist is a destroyer, a ravager, a harbinger of chaos. Ordinarily he is just the opposite. He is a builder, a reclaimer, a protector of the public welfare. In our scheme of national defense he lends his knowledge impartially to all departments. So it is that we find the most weighty matter of protection, including medical care and sanitation, the better for his existence. An army is only as good as the general health of its soldiers, and if our armies were subject to epidemics of such intensity as ravaged the camps in other days, wars would be much more sanguine affairs than they are. A better understanding of chemical principles, as applied to medicine, has done wonders toward combating disease and healing injuries in the hospitals of the battle field. The powerful anesthetics and preventives used in the last war saved untold suffering, while antiseptics and curatives have been developed to a degree that nine out of every ten men injured may be returned to active service. In work of this kind the chemist is performing an immeasurable benefit to humanity for all time.

The Scope of Chemistry

From its very nature, of being the *fundamental science of the transformation of matter*, chemistry is the most far-reaching, the most important of all sciences. Its interests are as many and varied as the manifold lines of human endeavor. And far from being fully developed, its surface, as yet, has barely been scratched. It is preëminently the science of the future.

The Future

In the domain of national defense its achievements have already been of all-encompassing and astounding character. It has been said that without chemistry every weapon but the bayonet becomes silent. Even this must be revised, for chemistry enters into the composition of the bayonet. Furthermore, it is in our power to make past accomplishment a mere fraction of future progress. By application of chemical concepts, by strengthening the chemical industries, and by furtherance of untiring research, we shall make it impossible for a people to place in jeopardy their existence as a nation. We shall provide securely for the enlargement of that science which is at once the most significant single principle in modern warfare, and the very essence of future national defense.

Bibliography

"The Riddle of the Rhine," Major Victor Lefebure.
"Creative Chemistry," Edwin E. Slosson.
"Everyman's Chemistry," Ellwood Hendrick.

"Chemical Discovery in the Twentieth Century," Tilden.
"Science Remaking the World," Caldwell & Slosson.
"Some Chemical Problems of To-day," Duncan.
"Chemistry and Peace," J. B. S. Haldane, *Current Opinion*, March, **1925.**
"Gas War," P. Mille, *Living Age*, December 27, **1924.**
"Chemistry in World Affairs," H. E. Howe, *Scientific American*, July–Sept., **1925.**
"Military and Industrial Explosives," Charles L. Reese, "Chemistry in Industry," Vol. II.

Protein Food Factors Found Necessary to Life. The discovery of the vital factors in food is progressing. To our knowledge of vitamins, calories, etc., science in the past decade has added information about the building stones or units of proteins, the amino acids.

Protein is found in such foods as meat, bread, cheese, etc. But proteins differ very widely on account of the different proportions of the amino acids constituting them as well as the arrangements of the amino acids in the large protein molecule. By varying the amounts and positions of these eighteen amino acids like eighteen blocks of a puzzle it is possible to build a few million different kinds of protein.

One of the most interesting of these amino acids is that one containing sulfur, known as cystine. Nutritional chemists have shown repeatedly that this is a necessary constituent of the protein food of young growing animals where growth and maintenance of health and body function are to be established. This proves that this amino acid cannot be synthesized in the animal body.

Sometime ago Prof. Carl P. Sherwin of Fordham University and co-workers proved this point by poisoning a dog with bromobenzene. As this compound requires cystine for its detoxication it was thought that the dog might be able to manufacture cystine in this case of dire necessity. But the dog was unable to do so even when the experimenters furnished it with carbon, hydrogen, oxygen, nitrogen and sulfur as compounds with its food.

Professor H. B. Lewis of the University of Michigan, department of physiological chemistry, who has done some excellent work in uncovering the chemical fate of cystine in the animal body, has recently carried out an interesting experiment. Quoting a report to the *Journal of Biological Chemistry:* "It has long been known that cystine is contained in hair, nails, hoofs, horns, and feathers in large amounts. Professor Lewis, in connection with R. H. Wilson, has carried out a most painstaking experiment in which he analyzed various samples of human skin and human hair, comparing them with sheep wool, feathers, rabbit hair, cat hair, dog hair and even tortoise shell.

"He finds that this amino acid, cystine, is exactly the same compound from any one of these sources, but that there is a decided difference in the proportion: human hair, fifteen and one-half per cent; sheep wool, twenty-one per cent; feathers, seven to twelve per cent; rabbit hair, eleven to twelve to fourteen per cent; rat hair, fourteen per cent; cat hair, thirteen per cent; dog hair, nineteen per cent; tortoise shell, six and one half per cent.

"The most interesting part of this experiment is that sex, color and race have little to do with varying the content of cystine in human hair."—*Science Service*

CHEMISTRY IN THE MINING INDUSTRY AS EXEMPLIFIED BY THE LEACHING PROCESS OF THE NEW CORNELIA COPPER COMPANY*

FRANK A. WHITELEY, BISBEE HIGH SCHOOL, BISBEE, ARIZONA

That we are living in an age of invention, an age of science, an age of research is a thought impressed upon our minds every hour, every moment of our daily existence. The wonders of the twentieth century surround us on all sides and almost confound our senses with their numbers alone. They dazzle our eyes, fill our minds with amazement, and instill in us a thirst for a knowledge and an understanding of these exploits of science. Research work in the natural sciences has been of the utmost consequence to the industrial advancement of the world. In many different fields of production has it been of great value; for example: in the development of the manufacture of coal-tar dyes, which touches the whole field of the textile manufacturing industry; of steel; and of bakelite.

FRANK A. WHITELEY

To all of the research work in the natural sciences, chemistry is indispensable. Chemistry is the science of the composition of all matter and, as such, is of paramount worth to the progress of the world. All industries of production—agriculture, manufacturing, and mining—are vitally dependent on chemistry for success, both in a financial way and in relation to the quality of their products.

In the mining industry, chemistry is of prime importance. Our country is exceptionally rich in the extent and value of its natural resources, particularly mineral, and even more particularly the metallic minerals. By mining, these metallic ores are extracted from the earth, sometimes from shafts extending many thousands of feet below the surface of the earth and sometimes from open pit mines. When these ores are found

* Prize-winning high-school essay, 1926–27.

in the mines, rough estimates may be formed of their values, but it is by chemistry that samples of the ores are assayed and the richness and percentage of each of the elements to be found in the samples accurately ascertained. The chemical assay determines beyond any doubt whether or not a body of ore may be mined at a profit or at a loss. In this way, every car of ore shipped from a mine can be accurately analyzed by the chemical assay of only a few samples of the ore. In all ore reduction plants—smelters and leaching plants—chemistry is most necessary, for without chemistry it would be impossible to reduce the metals from ores to the forms in which we desire them, except by very crude methods and with very impure and unsatisfactory results. Since only by means of chemistry can ores be accurately and thoroughly analyzed, and since it is only with the aid of chemistry that metallic ores can be reduced to pure metals, it is an unquestionable fact that chemistry is absolutely essential to the mining industry.

Whereas, chemistry has profoundly affected the whole mining industry, the great changes wrought by the use of chemical processes in mining are nowhere more in evidence than in copper mining. Copper, because it is corrosion-resisting, and because it is found in enormous natural deposits, is one of the most extensively used metals, and, consequently, one of the most extensively mined. Indeed, in the year 1926, 1,658,000 tons of copper were produced throughout the world, approximately sixty per cent of this being produced in the United States. About twenty-five per cent of the world's copper production in 1926 came from Arizona. (Statistics taken from the *Engineering and Mining Journal*, January 22, **1927.**)

Copper mining, being the greatest of Arizona's industries, is the one which has given her her wealth. The red metal is mined in almost every section of this vast state. At Ajo, Arizona, is found one of the best examples of the value and utility of chemistry to the copper mining industry.

The history of Ajo reads like a fairy tale. It is the story of untold wealth, worthless for centuries because of the lack of a means of turning it from its crude form into a form which could be used. The great Ajo ore bodies were known to the early Spaniards; American mining companies knew of them for generations; and they were slightly mined during the Civil War; but these oxide ore bodies were practically valueless until a chemical process was evolved by which the metallic copper could be extracted cheaply and profitably from the ore. Think of it! Millions upon millions of dollars of potential wealth in copper, lying dormant! —and all because of the lack of a practical means of converting that wealth into usable form! Mining company after mining company took an option on the property, only to give it up as "a bad job." At length, another company heard of the Ajo district. Its directors became in-

terested. They took an option. Its representatives made estimates of the millions of tons of ore contained in these great ore bodies. There was the ore! How were they going to develop it? They began to experiment and, as a sure expedient, resorted to chemistry. Then, figuratively, Aladdin rubbed his magic lamp; and the genie, at the command of Aladdin, went to the aid of the great corporation. This genie was chemistry. Chemistry, the science of unlimited powers, of unparalleled achievements, in truth, showed them the way. A chemical process was worked out in 1914 and was named the Greenway Process, its originator being the late General John C. Greenway. Knowing that the huge bodies of low-grade copper oxide ore could be reduced by this process to metallic copper, the New Cornelia Copper Company began to develop an immense open pit mine, founded the town of Ajo, erected a 5000-ton leaching plant and later a 5000-ton concentrator.

The Greenway Process is a leaching process by which copper is removed from low-grade oxide ore. Leaching is a method by which copper is extracted from oxide ore as a sulfate in solution. The action of sulfuric acid on the copper oxide changes it to copper sulfate, the chemical equation being $H_2SO_4 + CuO \longrightarrow CuSO_4 + H_2O$. The sulfuric acid, however, acts upon the copper carbonates, the cuprite, and a basic sulfate of copper in much the same way as upon the black oxide of copper, (CuO), forming in each case copper sulfate, ($CuSO_4$). This process, one of the marvels of chemistry, is the principal one by which copper can be taken from low-grade oxide ores profitably. The plant and process as used at Ajo are briefly described below.

There are, in the leaching plant, twelve tanks, each eighty-eight feet square and sixteen feet deep. They are arranged in rows of six. Of these tanks, eleven are used as leaching tanks and one as a settling tank. Seven tanks always contain ore which is being leached; the tailings in one tank are always being washed; one tank is always being excavated, *i. e.*, the ore which has been leached and washed is being removed; one tank is always ready to be excavated; and one tank is always being charged. Charging a tank means filling it with finely crushed ore. Each of the tanks at Ajo is charged with 5200 tons of ore. After a tank has been charged the actual leaching begins. A sulfuric acid solution, 0.9 per cent at first but later increased to 3 per cent, is pumped through holes in the floors of the tanks and thence up through the ore. The normal flow of the acid solution through the tanks is one thousand gallons per minute. The solution is circulated in a clockwise motion through the tanks containing ore which is being leached. An excellent feature of this process is that any per cent solution can be circulated through any tank or series of tanks at any time. Approximately seventy tons of 60° Baumé sulfuric acid, on an average, are used every day in the Ajo plant. The

copper sulfate solution formed by this process is one from which the copper may be removed by electrolytic methods.

The solution, after passing through seven tanks in a series, goes from the seventh, which is also the tank containing the newest ore, to the reduction towers. There are six towers arranged in pairs. They are built of sheet lead supported on a steel framework. Lead is used because of its resistance to the action of sulfuric and sulfurous acids. All the towers are filled with boards $^3/_8$ in. thick and 11 in. wide. These boards are placed on edge, the width of a board apart, and in layers. Each layer is laid at right angles to the one immediately below it. The solution is distributed through the tops of the towers in a showerlike spray, while sulfur dioxide gas is forced, by means of fans, up through the bottoms. The sulfur dioxide gas reduces the ferric iron in the solution to ferrous iron, the chemical equation being:

$$\underset{\text{Ferric}}{Fe_2(SO_4)_3} + H_2O + H_2SO_3 \longrightarrow \underset{\text{Ferrous}}{2FeSO_4} + 2H_2SO_4.$$

Ferric iron, because it tends to reoxidize the copper in the solution and since it necessitates an excessive use of power in the electrolytic plant, is harmful to the success of the process. Ferrous iron is not. Nowhere in the leaching process is the value of chemistry to the copper mining industry better illustrated than here. When the reduction of the ferric iron to ferrous iron has been completed, the solution flows into the settling tanks where the solid matter settles out. From the settling tanks the solution is pumped into the electrolytic plant. In this plant the copper in the solution, by means of electrolysis, is removed and built up into sheets of electrolytic copper weighing about one hundred and forty pounds each. Electrolysis is a process involving the discharge of the positive and negative ions in the solutions at their respective electrodes (anodes or cathodes). In the case of Ajo, thin copper sheets form the cathodes (electrodes having negative charges), and lead sheets form the anodes (electrodes having positive charges). When an electric current is passed through the solution, metallic copper is deposited at the cathodes.

The solution, discarded from the electrolytic plant but still containing some copper, is directed to a group of fourteen reinforced concrete launders —troughs—containing scrap iron. This process takes advantage of the law that one metal higher than another in the electro-potential series of metals will replace from its solution the one below it. Thus, in this case, $Cu^{++} + SO_4^{--} + Fe \longrightarrow Cu + Fe^{++} + SO_4^{--}$. The copper left in the solution is precipitated by the scrap iron in the form of cement-copper. This is washed from the iron, loaded into box cars, and shipped to the smelter.

The leaching plant and precipitation plant (plant for making cement-copper), at Ajo have been in continuous operation since June, 1917.

From that date until November, 1926, a period of eight and one-half years, 248,620,278 lb. of cathode copper were produced, in addition to 29,970,063 lb. of cement-copper. An enormous production, but just one more achievement due to chemistry.

The work of the New Cornelia Copper Company, when viewed alone, is of great magnitude; but, when viewed as a part of the entire copper mining industry it is found to be only a minute portion of the whole, all of which is dependent on chemistry for commercial success. But then the copper mining industry, however extensive it may be, is only a part of the mining industry taken as a whole, a whole to which chemistry is of the most signal worth. Yet the vastness of mining business is but a portion of the whole field of industry necessary to supply the needs of all the peoples of the world. Chemistry is in some way responsible for the advancement of each and every one of these industries.

Chemistry, industry; industry, chemistry—they are as one. They cannot be separated. For, since chemistry is the science of the composition of all matter, and since all industry has to do with matter and its composition, chemistry and industry are interwoven, are interlocked in a grip which will be strengthened and added to in the centuries to come. The maintenance of our civilization is dependent upon industry. The old processes would be incapable of the large scale production so necessary to feed, clothe, and house the multitudinous population of the modern world. Industry has had, and continues to have, great demands made upon it—demands that, without the practical application of the laws of chemistry, it could not meet.

Bibliography

1. Technical papers by:
   John C. Greenway,
   H. A. Tobelman,
   James A. Potter,
   Stuart Croasdale,
   H. W. Morse.
2. Personal interview with Mr. M. Curley, Manager of New Cornelia Copper Company.
3. Flow sheet of leaching plant made by draftsmen of New Cornelia Copper Company.

It is the successful, or even unsuccessful, pursuit of truth which gives happiness to each generation of scientific men, and not the value of the truth itself—the energy, the doing, not the thing done. If a time could arrive when all was known, when there could not be a new investigation or experiment, our keenest pleasure would be at an end. We may, therefore, feel happy in the thought of how much is still unknown.—A. G. VERNON HARCOURT

A GLANCE AT THE EARLY ORGANIC CHEMISTRY OF AMERICA

EDGAR F. SMITH, UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA.

Has the reader ever examined an American textbook on chemistry published a century or more ago, with the thought of what it might contain on organic chemistry? This query, probably, will bring the reply that textbooks of that early period, printed anywhere in the world, present very little relating to this domain of chemical science—so vast at present. Further, it would be queried as to whether whatever might be observed in those early textbooks printed in this country on the subject would not be a repetition of the material presented in the publications of foreign lands—especially those of England? This surmise would be perfectly correct.

Then, it would be discovered that there was no *organic chemistry*. Our fathers had not yet reached that thought. For them, *vegetable chemistry* and *animal chemistry* embraced what the modern designation, organic chemistry, includes. Wöhler had not synthesized urea.

One writer observed:

> The ultimate elements of vegetable and mineral matter are fewer, and are peculiarly well known. But the light which is thrown upon inorganic compounds, by resolving them into their ultimate elements, is much more satisfactory than any which we can, by the same means, extend to organic products. Ultimate analysis demonstrates between these, a difference, chiefly in the proportions of hydrogen, oxygen, carbon, or nitrogen, of which they are constituted; while in their influence on vitality, they display the opposite properties of the most delicious food, or the most deleterious poison, of delighting or offending our senses in the extreme.

And it was also said:

> A marked distinction between organic and inorganic products is that the latter can, in a much greater number of instances, be imitated by art.

Robert Hare, Nestor of chemical science in this Western Hemisphere, recalled a comment on this point by Rousseau who, having heard Rouelle's lecture on farinaceous matter, declared he would "not confide in any analysis of it, till corroborated by its reproduction from the alleged elements," which prompted Hare to say, "those who have any acquaintance with modern chemistry, will not be so skeptical," and naively continued:

> When diamond and charcoal are burned under different bell glasses, in different portions of the same oxygen gas, and in lieu of them, carbonic acid gas is found, in each vessel—who would hesitate to admit both substances to consist of carbon, because this element cannot be recovered in its crystalline form?

Such were some of the thoughts a hundred or more years ago, quite awhile before the little laboratory on the Lahn had come into existence, and none dreamed of the splendid messages which were to appear from the hands of its leader and his associates, shedding illuminating rays

upon the unclassified and uninterpreted facts included under the names of *vegetable chemistry* and *animal chemistry;* in the days when alcohol was considered as "constituted of one volume of aqueous gas, or steam, and one of the super-carburetted hydrogen;" and when it was proclaimed that organic (vegetable) substances were *acid*, *resinous*, or *oily*, or of an intermediate quality—hence could properly be treated, successively, under those general characteristics.

This is not the place to recite the various reactions which were applied to organic substances; yet they were industriously subjected to many and various reagents. That with nitric acid will suffice as an illustration:

Nitric acid has no other effect than to impart oxygen—giving rise to the same products as combustion; a result which ought not to excite surprise, as this acid is, in effect, composed of atmospheric elements, condensed into the fluid form, and containing that principle which is the most active. Owing to the volatility of nitric acid, many substances cannot be completely oxygenated by it, unless after several distillations. Repeatedly distilled from sugar, it produces malic acid first, and finally water and carbonic acid. These ultimate results are inevitably consequent to the ignition of the nitrates with dry vegetable substances—as, in this case, the alkali detains the acid, until the heat is adequate to produce a rapid reaction.

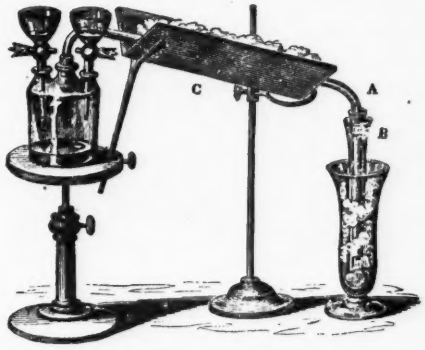


FIG. 1.—APPARATUS FOR THE GENERATION OF NITRIC ETHER

We welcome this peep into that ancient experimental work, forgetting for the moment our own numerous experiments in *nitration*, especially on viewing an early device, accompanied by the author's descriptive words, for the generation of pure nitric ether.

Let a tube, A, at least three feet long, and tapering from $^3/_4$ of an inch to $^1/_2$ an inch in diameter, be so bent at each end, that the larger may fasten air tight into the middle orifice, of a three-necked bottle, the smaller end entering another tube, B, standing nearly upright in a freezing mixture, in any convenient vessel. The tube, A, must be so inclined, that any liquid condensing in it, must run into the tube, B, and must be surrounded by a freezing mixture, supported about it, by the wooden trough, C. It has been mentioned, that, into one of the orifices of the bottle, one end of the tube is to be inserted. Let each of the two other orifices be furnished with a glass funnel, with a glass cock. Having made these arrangements, pour through one of the funnels about as much strong alcohol as will cover the bottom of the bottle nearly half an inch in depth. Next, by means of the other funnel, cautiously add as much concentrated nitric acid, as will cause an active ebullition. When the boiling relaxes, add more acid, and repeat the addition,

till it ceases to renovate the ebullition. In like manner, add more alcohol, till the evolution of vapour can no longer be excited in this way. Afterwards, resort may again be had to the acid. Meanwhile, the ether, generated by the process, will be condensed by the artificial cold in both tubes, and in consequence of their relative situation, will be deposited in the liquid form, in the smaller tube only.

It is a crude and cumbersome piece of apparatus; yet one may discern in it the dominant form which is used today for the same puprose. It must not be forgotten that the Liebig condenser, in its earliest design, had not appeared when the original of the sketch exhibited was applied in the preparation of nitric ether.

The device, just shown, was used by the singularly gifted Robert Hare, whose contributions to physics and general inorganic chemistry not alone challenge our admiration but cause us to marvel at their fresh originality. One is almost astounded at his observations, on slowly "mulling over" what he did in the organic field in days far gone.

Saturated with the great wealth of precious products obtained through the agency of synthetic organic chemistry, one is disposed to be impatient when any reference is made to the work of the fathers of our science, but this petulancy will disappear upon studiously considering that work. It is then that we recognize its intimate connection with work of the present; it is then that we appreciate its place in the comprehensive unfolding and development of the science.

FIG. 2.—INFLAMMABILITY OF SULFURIC ETHER ILLUSTRATED

In leafing over Hare's *Compendium* one encounters many most interesting observations. Everywhere throughout the various editions of this text the author not only gave a descriptive account of the various substances but invariably had recourse to what he designated "experimental illustrations." Thus he commented at length on the properties of sulfuric ether and exhibited its "surprising inflammability" by the extremely simple device before you, while his accompanying words were:

> The inflammability of sulphuric ether may be illustrated by applying the flame of a taper to a jet of it, while passing through the air, as represented in the figure. Under these circumstances, the ether is converted into a continuous arch of flame.
>
> The jet may be produced by compressing the bag with the hand, or by heating the bulb containing the ether, so that the pressure of the vapour generated by ebullition, may propel the liquid in a stream from the capillary orifice. If the latter method be adopted, the bag may be dispensed with.

This experiment was originally performed a century ago. Presumably it was striking in its effect, and those who saw it scarcely imagined

that the volatile substance, a quarter of a century later, would startle the medical world by its profound anesthetic powers.

In another ancient text, if so designated it may be, it was said that

> Ethers may be distinguished into three classes: those which are produced simply by abstracting from alcohol a portion of the aqueous vapour, those which arise from substituting a volume of an acid vapour for that of water in alcohol, and those which result from a combination of alcohol with an acid.

This quotation is introduced merely to arouse the thought of the reader, to incite him to compare the "olden time" ideas and views with those of the busy and alert present.

In glancing through another American *Manual of Chemistry* for 1825 the following observations on *Indigo* were met:

> It is a substance of a deep blue color, containing about 50% of pure coloring matter, which is perfectly insoluble in water. When heated it sublimes in the form of a blue smoke, which on condensation, forms acicular crystals. It is soluble in concentrated sulphuric acid. This solution is usually called *Saxon* or *liquid blue*. It is used as a substantive color for dyeing cloth and silk. Substances which powerfully attract oxygen render indigo *green*, and by exposure to air, it again acquires a blue color. In this green state indigo is soluble in the alkalies, and the solution is commonly employed for dyeing calico. A bath for this purpose may be made by mixing one part of indigo, two parts sulphate of iron, and two of lime, in a sufficient quantity of water: in this case the sulphate of iron is decomposed by a portion of the lime. The protoxide of iron thus produced becomes peroxidized at the expense of the indigo, which is rendered green and soluble in the alkaline liquor; cotton steeped in this solution acquires a green color, which by exposure to air, and washing in water acidulated with sulphuric acid, becomes a permanent blue.

This is not a very stirring description, but the color had attracted attention, and means for its utilization were being sought. The spirit of progress was evident, and confirmed by an appended suggestion for the analysis of the indigo to arrive at the quantity of actual coloring matter in various samples. This was roughly ascertained by the successive action of water, alcohol, and muriatic acid upon the submitted sample.

The preceding quotation is from "A Manual of Chemistry" by John White Webster, dedicated to John Gorham, M.D., Erving Professor of Chemistry in Harvard and also to James Jackson, M.D., the professor of Theory and Practice of Physick in the same University.

In a later edition of Hare's *Compendium*—the edition for 1840—a notable feature is that the space devoted to animal and vegetable chemistry is much extended and that these names so frequent twenty years earlier are replaced by the designation *Organic Chemistry*. Was this due to a widening influence of Wöhler's urea discovery or to Liebig's work? The author now notes that *carbon* is preëminently essential to the constitution of organic bodies and that it

> had been alleged to perform, in vegetables and animals, a part analogous to that which silicon performs in minerals.

The idea of radicals had gained ascendency and in describing cacodyl it was observed:

> It is one of the many compound radicals of which the existence has lately been inferred by chemists. It has the unusual feature of containing.....one atom of a metallic radical, *arsenic.*

What would the fathers have said of the important arsenic derivatives known today?

One follows, too, with an absorbing interest, the meritorious investigation of Proctor (1842) on the oil of *gaultheria procumbens* and that of *spiraea ulmaria* quite prepared to applaud the brilliant successes which attended his efforts and ready to express the hope that they may "be emulated by many of his countrymen."

Eager to learn how urea was considered in 1840, search was made and it was found to be *Anomalous Cyanate of Ammonia,* discovered in urine by Fourcroy and Vauquelin, and produced by "Wöhler as the first organic compound artificially produced (1828)."

For some reason it was expected that this synthesis would be treated in glowing terms! But evidently the ecstasy it occasioned at first, not only in Berzelius but in many others, when the discovery was originally announced, had passed away and on reaching these distant shores it was no longer susceptible of revival. However, old American textbooks do have considerable to say of the uric acid derivatives obtained by Wöhler and Liebig.

In the course of their remarks on fermentation one of the early American chemists dwelt quite at length upon catalysis and wrote:

> Water is powerful both as a *catalyzer* and as a solvent.

But, by this time, the reader may be wondering as to the nature of experimental work or investigation conducted in those early days in this country. Answers are found among others in the following examples:

> Artificial camphor was obtained by Hare (1839) on "impregnating oil of turpentine with dry hydrochloric acid gas." The pinene present in our American oil of turpentine, when acted on with the dry gas, made this synthesis possible.

Still another synthesis, from the same laboratory, was that of ethyl perchlorate, obtained by the interaction of crystallized sulfovinate of baryta and its equivalent of barium perchlorate. The product was described as a transparent, colorless liquid, heavier than water; exploding by ignition, friction, or percussion and sometimes without any assignable cause. The discoverers of this intensely interesting body said:

> This is the first ether formed by the combination of an inorganic acid containing more than three atoms of oxygen with the oxide of ethule, and that the chlorine and oxygen in the whole compound are just sufficient to form chlorhydric acid, water and carbonic oxide with the hydrogen and carbon. It is the only ether which is explosive

per se. The violence and readiness of its explosion are not surpassed by that of any other known compound. By the smallest drop, an open porcelain plate may be reduced to fragments, and by a larger quantity to a powder. In consequence of the force with which it projects the minute fragments of any containing vessel in which it explodes, it is necessary that the operator should wear gloves, and a close mask, furnished with thick glass plates at the apertures for the eyes, and perform his manipulations with the intervention of a movable wooden screen.

It is doubtful whether this discovery is credited, in any modern text, to its true originators—Clark Hare and Martin Boyé. The first of these was the eldest son of Robert Hare. He had studied with his father and in England with Sir Humphrey Davy and other distinguished chemists of that period. Clark Hare, though a most promising chemist, abandoned his science, and became in due course, a very eminent judge and professor of law in Philadelphia. His associate, Martin Boyé, was a Dane who came early to this country and in the eighteen forties was one of the assistants of Robert Hare. The writer enjoyed the honor of sitting at the side of Boyé, at a dinner participated in by the most renowned scientists of the land. Boyé was then 96 years old. He had studied with Berzelius. When interrogated as to ethyl perchlorate he poured forth most interesting facts on the history and properties of this singularly striking body.

If it might be our privilege to sit at the feet of the Gamaliels of our science, the very distant past would breathe again with renewed animation and the inspiration which would come to us can scarcely be imagined. Thus it seemed to the writer, as he silently absorbed Boyé's story of his hours of intimate contact with Berzelius. What must have been his estimate of Robert Hare? The question was asked. The answer was one of extreme praise, and closed with the words, "Hare was a giant." And yet so little has been known of his marvelous achievements; further, he was a real pioneer in organic investigation as the examples previously cited attest.

Martin Boyé could not refrain from alluding to Robert Hare's experiences with fulminating powder which he made by mixing an equivalent of lime with an equivalent and one-half of bicyanide of mercury, then introducing the mixture into a porcelain crucible placed in an air-tight alembic of iron so as to completely expose it to a red heat. When the residual mass was dissolved in acetic acid, the solution filtered, and the resulting precipitate produced by mercurous nitrate washed and "well dried it was found to constitute a powder capable of fulminating by percussion."

On one occasion Hare was badly injured by the explosion of fulminating silver, which prompts the statement that it has always seemed remarkable that so many of the fathers occupied themselves with the fulminates. What secret attraction did these bodies possess? Not only Wöhler,

Liebig, and others abroad, but Hare, Woodhouse, Cutbush, and many American chemical worthies gave much time and thought to these unstable derivatives. Then, there was also Samuel Guthrie (1831) who wrote to Benjamin Silliman:

> I am somewhat chagrined by reading your observations on fulminic acid, etc., to find myself anticipated in what I was about to claim as a discovery of my own, to wit, that fulminic acid could be *transferred* to caustic potash, and a salt obtained from the union; and that that salt, at less than a boiling heat, would be decomposed, and yield *ammonia*.

Concluding,

> After all, I have only verified M. Liebig's discovery of fulminic acid, and devised a detonating compound of tremendous power, which can be prepared with more safety, and at less expense than detonating silver.

Guthrie was, certainly, pursuing interesting paths and applying most original methods of procedure, so that Silliman justly remarked: "I am impressed with admiration both at his skill and intrepidity."

And this bold experimenter was the same Samuel Guthrie who, in 1831, reading about the Dutch liquid and its physiological relations, conceived that he might obtain chloric ether (Dutch liquid) in greater abundance and at a cheaper cost by distilling together alcohol and bleaching powder. His success was remarkable. He obtained not ethylene chloride (Dutch liquid) but an alcoholic solution of chloroform in great abundance, describing his process in Silliman's *Journal of Science* a little later. He had indeed won chloroform, which therefore may be claimed as an American discovery: for Guthrie was not aware of similar researches by Liebig, Dumas, and Souberain, the latter of whom in 1832 called the product "a new ethereal liquid of a constitution unlike any before known to chemists."

To Dumas (1834) we are indebted for its name (chloroform) and for the revelation of its true constitution.

This splendid discovery is so inspiring that Guthrie's own words deserve a hearing:

> Into a clean copper still, pour three pounds of chloride of lime and two gallons of well flavored alcohol of sp. gr. 0.844 and distil. Watch the process, and when the product ceases to come highly sweet and aromatic, remove and cork it up closely in glass vessels. . . . , . By distilling the product from a great excess of chloride of lime, in a glass retort, in a water bath, a greatly concentrated solution will be obtained. The new product is intensely sweet and aromatic. By distilling it from carbonate of potash, it will be concentrated and refined. By distilling it from caustic potash, the ether is decomposed and muriate of potash is thrown down, while the distilled product consists of alcohol.

In a second paper Guthrie gives in detail a method for testing the purity of chloroform by agitating it with concentrated sulfuric acid.

He was also the first (1832) to publish an account of its therapeutic effects as a diffusible stimulant.

Indeed, in these memorable discoveries he was a benefactor of mankind. Think for a moment of the benign influence of chloroform as an anesthetic; for

There is
No danger in what show of death it makes,
More than locking up the spirits for a time,
To be more fresh, reviving.

This is a chapter of home endeavor in the organic division of our science in which we may well rejoice. It was written in a now "historical laboratory" located in the wilds of the State of New York, away from seats of learning and remote from the arteries of commerce, by a man of medium stature, slender build, dark complexion, slightly stooping figure and thoughtful mein, whom even the close observer of the throng in New York, in which he frequently mingled, would not recognize as a man whose fame as the discoverer of chloroform, and whose work in other original scientific investigations gave him rank among the eminent men of that early period.

Other instances of the experimental activity of early American chemists might readily be given; indeed, it was the writer's intention to prepare a sketch of the "rise and development of organic chemistry in America," but as he gathered in the bright sheaves they grew in multitude so rapidly that he thought it unjust to try to give them briefly, because they deserved an ample and complete presentation, so he contented himself with "a glance at the early organic chemistry of America."

Why should not some enthusiast in organic chemistry give himself to assembling and offering the observations made in this branch of chemistry as a separate and distinct chapter? It would repay every outlay of effort. Further it would show that though the labors of the fathers were crude and of a pioneer character, they were meritorious beginnings, having actual and genuine value.

Synthetic Thyroid Hormone Works Like Natural Product. The chemical composition of the active principle of the thyroid gland has finally been completely established by Dr. C. R. Harington, and Prof. George Barger of University College, London.

These workers, who have received widespread recognition for their successful attempt to manufacture the hormone in the laboratory about a year ago, have definitely ascertained the position of the iodine atoms in the complex thyroxin molecule.

Clinical tests show that the synthetic product will reproduce the results of the natural thyroxin in cases of thyroid deficiency, the metabolic rate having been raised from minus 40 per cent to normal in the course of a week by three or four intravenous injections of 4 to 5 milligrams on alternate days, it is stated in a report of the research to the scientific journal, *Nature.—Science Service*

THE BALANCING OF OXIDATION-REDUCTION EQUATIONS. II.

ERIC R. JETTE, NEW YORK UNIVERSITY, AND V. K. LAMER, COLUMBIA UNIVERSITY, NEW YORK CITY

Applications of the Ion-Electron Method[1]

Before applying the method just discussed to some typical cases encountered in inorganic chemistry, it will be pertinent to remind the reader that simply calling this method the "ion-electron" method is hardly a sufficient reason for limiting its use strictly to those equations in which only ions appear. There are many cases where non-ionic substances appear and yet the reactions satisfy all the conditions demanded by the underlying principles. We will continue, however, to limit the discussion to reactions in aqueous solutions.

The Action of HNO_3 on Metals

Among the more troublesome equations to balance are those for reactions of HNO_3 on the metals. These cases are complicated by the fact that the reduction product of the NO_3^- ion depends upon the position of the metal in the electromotive series, the concentration of the acid, the temperature, the physical state of the metal (the use of finely powdered or large pieces) and the depth of acid in the test tube. The reduction of NO_3^- ion may thus result in any one or several of the following: N_2O_4, NO_2^- ion, NO, N_2O, NH_2OH, N_2 and NH_4^+ ion; if a very active metal is used with a very low concentration of NO_3^-, the H^+ of the HNO_3 is discharged to form H_2. As usually carried out, the reduction of the NO_3^- results in several of the possible products but one of them may predominate.[2]

The following points must be noted:

(1) If the right side of the equation contains more than one reduction product of the NO_3^- ion, the equation is meaningless because the different products result from several reactions taking place simultaneously and the products are not in the stoichiometric proportions which the equation would imply. A separate equation must be written for each reduction product.

(2) Hydrogen ion is always consumed in the course of reducing the NO_3^- regardless of the final product.

(3) Each reduction product of the NO_3^- ion involves a particular electron change.

[1] This method was outlined in "The Balancing of Oxidation-Reduction Equations. I." See THIS JOURNAL, **4**, 1021–30 (Aug., 1927).

[2] J. G. Brown, *J. Phys. Chem.*, **25**, 429 (1921); W. Bancroft, *ibid.*, **28**, 475 (1924); L. H. Milligan, *ibid.*, **28**, 545 (1924); N. R. Dhar, *ibid.*, **29**, 142 (1924).

The three partial equations applying to the most common cases are:

$$NO_3^- + 2H^+ + 1\epsilon \longrightarrow NO_2 + H_2O$$
$$NO_3^- + 4H^+ + 3\epsilon \longrightarrow NO + 2H_2O$$
$$NO_3^- + 10H^+ + 8\epsilon \longrightarrow NH_4^+ + 3H_2O$$

The first applies to the action of concentrated (68%) HNO_3 on *all* metals. (The case of the noble metals is given later.) The second applies to the action of dilute HNO_3 on metals such as Zn and Fe. It is not practical to define the concentrations more exactly in view of all the other variable factors involved (see above). The partial equations for the various metals involve no difficulty.

The Solution of Sulfides

Most sulfides are dissolved by HCl or H_2SO_4, due to the weakness of H_2S as an acid and the high concentration of H^+ ion which can be secured in solutions of HCl or H_2SO_4. The more exact treatment of these cases can be found in textbooks. Occasionally, however, a metallic sulfide is too insoluble, (*e. g.*, CuS) for this procedure to work and the sulfide concentration must be diminished by oxidation, *e. g.*, by HNO_3. The $S^=$ ion thus acts as a reducing agent and its partial equation is:

$$S^= - 2\epsilon \longrightarrow S^\circ$$

As the partial equation for the NO_3^- we can use either the first or second (no other) given above, depending on whether concentrated or dilute acid is necessary.

The partial equation for the sulfide ions, remembering that their concentration is very low and that in this example their source is the insoluble CuS,[3] becomes

$$CuS - 2\epsilon \longrightarrow Cu^{++} + S^\circ$$

The final equation for concentrated acid, is:

$$CuS + 2NO_3^- + 4H^+ \longrightarrow Cu^{++} + S^\circ + 2NO_2 + 2H_2O$$

The Action of Aqua Regia

Sometimes we find that the ordinary acids do not dissolve certain substances and we resort to a particularly powerful solvent made by mixing HNO_3 with HCl. The action of this mixture (aqua regia) has usually been misinterpreted, its "dissolving power" being variously ascribed to the presence of "nascent" or of free chlorine, nitrosyl chloride (NOCl), etc.

To get properly oriented in this matter we must first recall the activity or electromotive series of metals. At the top of this series we have metals whose atoms have a great tendency to lose electrons: thus, $K^\circ - 1\epsilon \longrightarrow K^+$; $Mg^\circ - 2\epsilon \longrightarrow Mg^{++}$. As we go down in the series, it

[3] Cf. the discussion of the HgS case.

becomes more and more difficult to remove these electrons from the atoms. At the bottom of the list, to remove the electrons from the metal atoms requires the presence of substances with very great tendencies to take on electrons, *i. e.*, very powerful oxidizing agents. A second point is that a metal not only can lose electrons but its ions can take on electrons and thus we must consider the metal, its ions, and the electrons as forming an equilibrium, *e. g.*, $M^\circ - 1\epsilon \rightleftarrows M^+$, the extent of which in the forward direction is indicated by the position of the metal in the e. m. f. series. Exactly the same thing is true of the oxidizing agents such as HNO_3; it is not only possible to have the action:

$$NO_3^- + 2H^+ + 1\epsilon \longrightarrow NO_2 + H_2O$$

but under the proper conditions we can get:

$$NO_2 + H_2O - 1\epsilon \longrightarrow NO_3^- + 2H^+$$

Therefore the whole oxidation-reduction reaction is a reversible equilibrium. As these reactions are usually carried out, we can often, but not always, neglect the backward tendency entirely.

For example, a characteristic property of the noble metals is the great ease with which their ions Au^+, Au^{+++}, Pt^{++}, Pt^{++++}, etc., return to the metallic state by gaining electrons. If Au or Pt is to be oxidized to the ionic state with our available oxidizing agents, we find that the equilibrium must be displaced in the forward direction by diminishing the concentration of these ions. One of the most convenient ways of accomplishing this is to promote the formation of one of the stable complex ions such as $(AuCl_4)^-$, $(PtCl_6)^=$, etc. For this purpose we must supply not only an oxidizing agent but also a source of chloride ions. Aqua regia fulfils both requirements. The appropriate partial equation is, therefore:

$$Pt^\circ + 6Cl^- - 4\epsilon \rightleftharpoons (PtCl_6)^=$$

For the oxidizing agent in the case where concentrated HNO_3 is used in making the aqua regia, we get

$$NO_3^- + 2H^+ + 1\epsilon \rightleftharpoons NO_2 + H_2O;$$

hence the final ionic equation is:

$$Pt^\circ + 6Cl^- + 4NO_3^- + 8H^+ \rightleftharpoons [PtCl_6]^{--} + 4NO_2 + 4H_2O$$

Notice three things: (1) The principle of putting into the equation only substances which actually interact and which are actually formed has been followed. (2) The electron change in the Pt partial is -4ϵ which is exactly the same as would have been obtained in the change $Pt^\circ \longrightarrow Pt^{++++}$ and, (3) it has not been assumed that Cl_2 or NOCl are the oxidizing agents. There is no doubt that these substances are present but this is entirely incidental. Actual measurements indicate

that aqua regia, which contains these substances is a less powerful oxidizing agent than HNO_3.[4]

Nitric acid alone also fails to dissolve HgS, a substance even less soluble than CuS. In this case again the concentration factor is important. We must remember that the $S^=$ ion is being oxidized to S° and that this action is reversible also. Now HgS is highly insoluble and we have the equilibrium:

$$HgS\ (solid) \rightleftharpoons Hg^{++} + S^=$$

Thus as the concentration of either $S^=$ or Hg^{++} ions is increased, the concentration of the other ion decreases and less and less HgS dissolves. As the NO_3^- will not oxidize the $S^=$ ion if the concentration of the latter is too low, we find that only a minute amount of HgS goes into solution, because while the concentration of the $S^=$ ion is lowered by the oxidation, the Hg^{++}-ion concentration is increasing and less of the HgS can dissolve. To get around this situation we must diminish the Hg^{++}-ion concentration as well. Mercury also forms complex mercuri-chloride ions and it will be recalled that even $HgCl_2$ is only slightly ionized, being entirely different from most salts in this respect. Thus, if we add Cl^- ions we can reduce the Hg^{++}-ion concentration. Again the aqua regia furnishes the two things required, the oxidizing agent ($NO_3^- + H^+$) and Cl^- ions. Notice then that the partials for the oxidizing and reducing agents are the familiar ones and we can add a third to take account of the effect of Cl^- ions but no electron change is involved in it.

For concentrated HNO_3,

$$2 \times (NO_3^- + H^+ + 1\epsilon \rightleftharpoons NO_2 + H_2O)$$
$$S^= - 2\epsilon \rightleftharpoons S°$$
$$Hg^{++} + 4Cl^- \rightleftharpoons HgCl_4^=$$

or better, by combining the second two since the solid HgS is the starting point,

$$2 \times (NO_3^- + 2H^+ + 1\epsilon \rightleftharpoons NO_2 + H_2O)$$
$$HgS + 4Cl^- - 2\epsilon \rightleftharpoons HgCl_4^= + S°$$

$$HgS + 2NO_3^- + 4Cl^- + 4H^+ \rightleftharpoons HgCl_4^= + S° + 2NO_2 + 2H_2O \text{ (final ionic equation)}$$

Self-Oxidation-Reduction Reactions

In some reactions the same substance acts both as oxidizing and reducing agent, *i. e.*, some of the atoms, ions or molecules are being oxidized while others are being reduced. These are "self- or internal oxidations."[5]

[4] W. C. Moore, *J. Am. Chem. Soc.*, **33**, 1091 (1911); **35**, 333 (1913), finds that Cl^- lowers the oxidation potential of nitric acid, probably through catalysis of certain side reactions. The general principles involved in this section were recognized by Ostwald; cf. "Principles of Inorganic Chemistry" (Findlay translation), 3rd ed., p. 339, **1905**; 4th ed., p. 363, **1912**.

[5] Were it not for the fact that reactions in which molecular oxygen directly oxidizes a substance have been classified as auto-oxidations for many years, this term would be more appropriate than self- or internal-oxidation.

While such reactions cannot be performed successfully in separate vessels, the application of the ion-electron method frequently emphasizes the changes accompanying the oxidation-reduction. A case in point is given by HOCl which yields HCl and $HClO_3$ as its products.

$$2 \times (HOCl + H^+ + 2\epsilon \rightleftharpoons Cl^- + H_2O)$$
$$HOCl + 2H_2O - 4\epsilon \rightleftharpoons ClO_3^- + 5H^+$$
$$3HOCl + 2H^+ + 2H_2O \rightleftharpoons 2Cl^- + ClO_3^- + 2H_2O + 5H^+$$
$$3HOCl \rightleftharpoons 2Cl^+ + ClO_3^- + 3H^+$$

This equation emphasizes the fact that as the weak acid HOCl undergoes self-oxidation-reduction, the H^+ concentration increases. Two analogous cases yield:

$$3Cl_2 + 3H_2O \rightleftharpoons 5Cl^- + ClO_3^- + 6H^+$$
$$N_2O_4 + H_2O \rightleftharpoons HNO_2 + NO_3^- + H^+$$

In all three cases the equilibrium point is displaced to the right by the addition of a base (OH^- ion).

The Solution of Stannous, Arsenious, and Antimonous Sulfide by Ammonium Polysulfides

It can easily be shown that when, for example, the brown SnS is dissolved in ammonium polysulfide and the resulting solution of ammonium sulfostannate is then acidified with HCl, the precipitate consists of the yellow SnS_2 (plus sulfur). The metal has therefore been oxidized. The same thing can be shown for As and Sb but not in such a striking (visually) manner. The fact that these are oxidation-reduction reactions is obscured by the usual manner of writing the equations. We are certain that As_2S_3 turns up in the solution in the form of $AsS_4^{\equiv}$. But what is the oxidizing agent? Ammonium polysulfide is supposed to contain ions of the form $S_2^{=}$, $S_3^{=}$, $S_4^{=}$, $S_5^{=}$, etc., any or all of which can act as oxidizing agents according to the following partials:

$$(a)\quad S_2^{=} + 2\epsilon \rightleftharpoons 2S^{=}$$
$$(b)\quad S_3^{=} + 4\epsilon \rightleftharpoons 3S^{=}$$
$$(c)\quad S_3^{=} + 2\epsilon \rightleftharpoons 2S^{=} + S^\circ, \text{ etc.}$$

For the behavior of the As_2S_3, a number of partials are also possible.

$$(d)\quad As_2S_3 + 5S^{=} - 4\epsilon \rightleftharpoons 2AsS_4^{\equiv}$$
$$(e)\quad As_2S_3 + 5S_2^{=} - 4\epsilon \rightleftharpoons 2AsS_4^{\equiv} + 5S^\circ, \text{ etc.}$$

Until a more exact knowledge of the reaction is available, it is expedient to consider the sulfur, which has been added to the $(NH_4)_2S$ to make the polysulfide, merely as dissolved S° and to take as the partial

$$S^\circ + 2\epsilon \rightleftharpoons S^{=}$$

By combining this with (*d*) which is the simplest of the possible partials for the As_2S_3, we get

$$As_2S_3 + 5S^{=} + 2S^\circ \rightleftharpoons 2AsS_4^{\equiv} + 2S^{=}$$

and as the final molecular equation,

$$As_2S_3 + 2(NH_4)_2S + 2S \longrightarrow 2(NH_4)_3AsS_4$$

which is one of the common forms.

It is to be emphasized that the uncertainty as to which partial to choose for the oxidizing agent and for the reducing agent is not due to any shortcoming in the underlying principles of the ion-electron method, but results from the lack of exact knowledge of the reacting substances and final products. Without this knowledge any method of balancing becomes uncertain as was indicated at the start.

Finally we may note a few partial equations which, in addition to those already stated, may be useful to the student.

$MnO_4^- + 4H^+ + 3\epsilon \rightleftharpoons MnO_2 + 2H_2O$ in alkaline solution
$H_2O_2 - 2\epsilon \rightleftharpoons O_2 + 2H^+$ when H_2O_2 acts as reducing agent
$2S_2O_3^= - 2\epsilon \rightleftharpoons S_4O_6^=$ in the reaction with iodine and with acidified $KMnO_4$ under proper conditions
$I_2 + 6H_2O - 10\epsilon \rightleftharpoons 2IO_3^- + 12H^+$
$S^\circ + 4H_2O - 6\epsilon \rightleftharpoons SO_4^= + 8H^+$
$SO_4^= + 10H^+ + 8\epsilon \rightleftharpoons H_2S + 4H_2O$
$HNO_2 + H_2O - 2\epsilon \rightleftharpoons NO_3^- + 3H^+$ when HNO_2 acts as a reducing agent
$HNO_2 + H^+ + 1\epsilon \rightleftharpoons NO + H_2O$ when HNO_2 acts as an oxidizing agent
$NO_3^- + 7H^+ + 6\epsilon \rightleftharpoons NH_2OH + 2H_2O$ dilute acid on Sn
$S_2O_8^= + 2\epsilon \rightleftharpoons 2SO_4^=$ persulfate ion as oxidizing agent in weak acid or neutral solution
$SO_4^= + H_2O - 2\epsilon \rightleftharpoons SO_5^= + 2H^+$ formation of monopersulfate ion
$AsO_3^= + 9H^+ + 6\epsilon \rightleftharpoons AsH_3 + 3H_2O$ in acid solution
$CN^- + H_2O - 2\epsilon \rightleftharpoons CNO^- + 2H^+$ in alkaline solution

Discussion

It will be evident from the discussion of the methods for balancing inorganic oxidation-reduction equations, that the writers have made little attempt to make the balancing of these equations "easy" in the sense that they can be presented to any high-school student of chemistry with the expectation of successful results. The balancing of these equations cannot be made "easy;" however, it can be made logical, but only to students who have had sufficient training in the fundamental chemical facts and theories. By far the greater majority of high-school students are at no time during their high-school course sufficiently mature in their chemical studies to apply, *with understanding*, *any* method of balancing oxidation-reduction equations, nor does it seem at all essential, for the purposes of the high-school course, that they should be required to learn such methods. The writers feel convinced that it would be better for all concerned (including the student) if the teachers of elementary chemistry would consider each such equation simply as a whole and not attempt to give a method for balancing. High-school students, even at

the end of their course, can be expected to have only a very slight appreciation of the concepts of valence, ions, equilibrium, etc. The methods of balancing which they have usually been taught, generally avoid the use of these concepts by employing the most ancient and limited definition of oxidation which is "the addition of oxygen or the subtraction of hydrogen." This results in balancing the equations by means of active or "nascent" oxygen or hydrogen. Such methods should be discouraged as they almost invariably prove to be a hindrance rather than an aid in the students' more advanced work. Concerning those students who never take any courses in chemistry beyond the high school, the writers believe that it is altogether unimportant whether or not they are able to balance a complicated oxidation-reduction equation but for those who continue their studies the lack of any knowledge of methods of balancing is preferable to knowing one which is misleading.

In college and more advanced courses there seems no reason why the student should not be taught methods which involve something more than the application of artificial rules with a subsequent arithmetical juggling of coefficients. This is, of course, partly a question of preference and if the teacher merely desires that the student be able to write a balanced molecular equation for an oxidation-reduction reaction in exactly the same manner as he does for an ordinary double decomposition reaction, then any method will suffice, regardless of how limited its scope or how improbable its assumptions may be.

However, the teacher may desire to discuss oxidation-reduction reactions in a way which brings out their fundamental features and at the same time emphasizes how the direction and the extent to which a given reaction proceeds can be controlled by applying the equilibrium concepts which the student has already studied. In this event the methods of balancing presented above will be of service. This is especially true of the ion-electron method.

From the pedagogical standpoint the writers have found certain features in the mode of presentation which may be of interest. The division of the oxidation-reduction reactions into two groups has proved useful in stressing the fact that, while all chemical actions probably have the same underlying mechanism, our present knowledge does not permit us to consider all reactions as belonging to one class, *e. g.*, ionic. At the present time, it would obviously be quite as absurd for a chemist to state that all reactions are ionic as it would be for a biologist to classify all living organisms as plants. The student, however, is quite likely to think of reactions in general as being ionic or non-ionic depending on the textbook he has used and his teacher. The ionization theory, like many other good things, can be and frequently has been worked to death. Incidentally, it does the student no harm to realize that chemistry is not

a completely developed science and that much fundamental work still remains to be done.

The ion-electron method serves, on the other hand, as an additional and profitable means of emphasizing the various factors entering into ionic reactions. The student can be shown that the weak electrolytes play important parts in many reactions because of their low degree of ionization and that these reactions are not limited to neutralization and hydrolysis. The solubility of a substance may be shown to be a deciding factor in other than double decomposition reactions involving precipitates. The formation of a complex ion can also appear as a requisite to the progress of an oxidation-reduction reaction.

The ion-electron method, by accentuating the essential changes which have occurred, also brings out the things which the student does not know. An excellent example is the sort of reaction which frequently occurs in qualitative analysis, namely, the oxidation of $FeSO_4$ by HBrO in the presence of a strong acid such as HCl. The ion-electron method yields:

$$2Fe^{++} + HBrO + H^+ \rightleftharpoons 2Fe^{+++} + Br^- + H_2O$$

The final molecular equation becomes extremely complex and appears quite different depending on which combination of the possible final molecular products, $Fe_2(SO_4)_3$, $FeBr_3$, $FeCl_3$, H_2SO_4, HBr, and H_2O is chosen. The writers have obtained four different equations, each one of them being stoichiometrically correct, and the possibilities were by no means exhausted. Incidentally, any one of these equations might have been obtained by applying the valence change or a "nascent" oxygen method. Without a complete knowledge of the phase equilibria of this system, it is impossible to say with which negative radical the iron will be combined, and even if such information were available the product which the student would obtain if the solution were evaporated to dryness would depend to some extent on how fast the evaporation was effected rather than the phase equilibria. In other words, the ionic equation expresses all that the student has any opportunity of discovering from his own observation. Why insist upon a totally arbitrary molecular equation?

It may be objected that presenting the ion-electron method involves the introduction of electro-chemical considerations at a comparatively early stage. There would, of course, be no particular object in frightening a student by telling him that he is learning something about electro-chemistry. There is, however, just as little possibility of discussing oxidation-reduction reactions in any adequate and reasonable manner without introducing the idea of the transfer and flow of electrons as there would be to discuss electro-chemistry without mentioning oxidation-reduction. The writers have found that students who have learned to

apply the ion-electron method never have any difficulty in handling the chapter on electrochemistry which is usually placed toward the end of the textbook, and consequently glossed over.

The writers have also found that when the students are acquainted, even in a very elementary way, with the modern idea of atomic structures as positive nuclei surrounded by electrons, they readily appreciate the logic of considering oxidation-reduction reactions in terms of a transfer of electrons.

Finally, it may be added that while in the present article a large number of examples for the application of the ion-electron method have been brought together, it is not intended to suggest that all of these should be given to the student in consecutive lectures. After the foundations for the method have been laid, the applications may be introduced whenever suitable to the text or lecturer. It is well that the applications be spread out over a long period for the student meets with oxidation-reduction reactions all the way through his courses on inorganic and analytical chemistry.

The writers wish to thank Professor James Kendall, Dr. C. V. King, and Dr. J. J. Beaver for reading the manuscript and for their suggestions concerning various points.

Summary

The proposition is advanced that the aim in the balancing of an oxidation-reduction equation should not be merely to secure a stoichiometrically correct final equation but that the method applied should emphasize the fundamental phenomena of this class of reactions and take into account whatever other factors may be involved in a particular case which may modify the course of the reaction.

The ideal method of balancing would be one which could be applied to all oxidation-reduction reactions but, unfortunately, it is not expedient to devise such a scheme in the present state of chemical knowledge. The inorganic oxidation-reduction reactions have been divided, somewhat arbitrarily, into two groups, (*a*) those which are essentially non-ionic in character and (*b*) those which take place in aqueous solution. The simple "valence change" method is briefly described in connection with the first group.

A more detailed discussion of the "ion-electron" method is given for application to the second group. It is shown that this method has a sound experimental basis and that it is sufficiently general to hold for all inorganic oxidation-reduction reactions taking place in aqueous solution. It is stated as a principle of the method that only those substances, the amounts of which are changed in a significant manner during the course of the reaction, will be included in the equation. The rules for the method

are given and applied to a number of typical cases where modifying factors such as acidity, solubility, degree of ionization and complex-ion formation, etc., are involved. Certain pedagogical features are also discussed.

Electric Current Used to Make Rubber Castings. Inner tubes, water bags and other articles of pure rubber, stronger and more durable than rubber obtained by any other process, are now being made by electric moulding, essentially the same process that is used in electroplating silver ware and in making cuts for newspaper pictures, according to the Engineering Research Foundation. The process was worked out by two groups of researchers, one in America and one in Hungary, neither of whom knew that the other was engaged in the problem. The American workers were S. E. Sheppard and L. W. Eberlin of the Eastman Kodak Company, and the Hungarian group was led by Paul Klein and A. Szegvari.

"Both groups were practically interested in improvement of the quality of rubber goods," an official of the Engineering Research Foundation states. "They knew that when the solid dried crude rubber is worked upon a mixing mill in the rubber factory, the rubber substance was made softer and weaker. They knew that the less rubber was heated or worked, the better was its quality. They also knew that research of chemists in recent years had shown how vulcanization may be carried on at lower temperatures than formerly and the necessary sulfur combined with rubber with minimum of loss of quality. Certain substances known as accelerators possess the property of permitting vulcanization to be accomplished at relatively low temperatures. However, if these accelerators were incorporated on the usual mixing mill, the temperature would be sufficiently high to cause vulcanization during mixing and spoil the goods.

"These men conceived the plan of so depositing rubber on forms, from latex, that the rubber particle itself was not altered, and made the astonishing discovery that electro-deposited rubber had the highest quality ever observed. There were many problems to be solved before this was made practical. It was necessary to incorporate other substances to be deposited simultaneously, such as sulfur, zinc oxide, and carbon black. These latter two substances are necessary in rubber goods to give toughness. A long investigation was carried out to find means to disperse them in water, mixed with the latex particles, without coagulating the latex. A noteworthy achievement has been the discovery of means by which these rubber layers may be made free from bubbles, for when an electric current is passed through a solution, bubbles of gas are formed on anode and cathode. So they hit upon the scheme of surrounding the anode with a porous clay diaphragm. The anode is, therefore, immersed in electrolyte inside a porous clay cell or dish and the rubber particles together with those of zinc oxide, sulfur, etc., are deposited upon this porous so-called anode diaphragm. Thus the rubber as it collects forms a continuous, homogeneous, tough covering of uniform thickness. Any thickness up to an inch or more is practicable. Rubber thus formed is stronger than rubber prepared by the old methods, and is free from gas or air holes.

"Industrial development is already well advanced. Continuous, automatic production of certain kinds of articles is feasible. Manufacture of inner tubes for automobile tires is the most important application, if quantity be the criterion. Bathing caps, stationer's elastic bands, tobacco pouches, and hot-water bottles are other examples. Insulation for wires and other things electrical is another application. No high temperatures are used. For impregnating textiles the rubber can be more intimately applied to the fibers."

British and American interests, it is stated, have united to form a corporation to bring goods manufactured by the new process on the market in large quantities.—*Science Service*

AN EXPERIMENT IN PREDICTING PERFORMANCE IN GENERAL CHEMISTRY

MAUDE B. SCOFIELD, SYRACUSE UNIVERSITY, SYRACUSE, NEW YORK

Every year large groups of freshmen with widely varying abilities are required to take chemistry in our universities. The problem of recognizing these varying abilities at the beginning of the course is a live one and administrators are becoming more and more conscious of the responsibility which it involves. Attempts to solve it by use of the experimental method have been the subject of a number of articles in THIS JOURNAL.

The students in general chemistry at Syracuse University are divided into two groups: those who have studied chemistry before and those who have not. This paper deals with the former group which normally numbers two hundred.

In September, 1925, a few simple preliminary chemical tests were given in an effort to section the class on the basis of ability. The results of these tests indicated that the high-school preparation of our students in chemistry and the time which elapses after the preliminary course varies so widely that any chemistry examination may prove to be only a memory test. For sectioning purposes, we are concerned more with what students can do in college chemistry than with what they may have remembered.

In September, 1926, we again devised a placement examination. This time the tests were based upon the assumption that success in the general course will be determined by the following factors: (1) whether the student pays attention; (2) whether he is inclined to follow directions —this applies to laboratory work or any other assignment; (3) whether, given a few facts, he can reason logically and consistently, or given a general rule, can he apply it to a specific case; (4) whether he can perform simple arithmetical processes which involve the placing of the decimal point; (5) whether he can work problems which involve the use of direct and inverse proportion as well as exercise "arithmetical common sense" in handling percentage problems.

The tests we devised to measure the inclination to pay attention and to follow directions did not give satisfactory results. But the outcome of the tests on the last three points was interesting. Following is the examination:

Part I (5 Credits)

1. What is one and six-hundredths per cent of five-hundred-sixty?
2. Express nine-hundred-seventy-five ten-thousandths as per cent.
3. Multiply eleven and eleven-hundredths by five-thousandths.
4. Divide six and six-tenths by twenty-two-thousandths.
5. Subtract five and fifty-two-thousandths from ten and four-hundred-fifty-five-thousandths.

Read the notes before trying to answer any questions in Part II. Then answer questions in the order given. Place answers opposite questions. Use back of question paper if scrap paper is desired.

Notes

Here is listed a part of the electrochemical series of the metals, giving names and symbols.

1. Potassium, K	7. Aluminum, Al	13. Cobalt, Co	19. Bismuth, Bi
2. Sodium, Na	8. Manganese, Mn	14. Nickel, Ni	20. Antimony, Sb
3. Barium, Ba	9. Zinc, Zn	15. Tin, Sn	21. Mercury, Hg
4. Strontium, Sr	10. Chromium, Cr	16. Lead, Pb	22. Silver, Ag
5. Calcium, Ca	11. Cadmium, Cd	17. Hydrogen, (H)	23. Platinum, Pt
6. Magnesium, Mg	12. Iron, Fe	18. Copper, Cu	24. Gold, Au

The activity of the metals decreases in the order given by the electrochemical series of the metals. That is, potassium is the most active and forms compounds which are the most stable while gold is least active and forms compounds which are most easily decomposed. All metals which stand above (H) in the series can replace it. Any metal in the series can replace all others below it in a compound. (Example: $Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$, or simply, zinc replaces copper.)

The chlorides of all the metals of the above series are soluble in water except $PbCl_2$, AgCl, HgCl.

All the nitrates of the series are soluble in water.

All the sulfates of the series are soluble in water except $BaSO_4$, $SrSO_4$, $PbSO_4$.

Most fluorides of the series are insoluble in water but the fluorides of K, Na, NH_4, Cu, Ag are soluble. All fluorides are soluble in dilute acid.

HgO and Ag_2O lose all their oxygen at 1000°. CuO will lose none of its oxygen while Bi_2O_3 and Sb_2O_3 lose part of their oxygen at that temperature.

The maximum temperature available from the Bunsen burner is approximately 1000°.

Zinc melts at 419° C. (C. indicates Centigrade degrees). Zinc boils at 918° C.

Zinc oxide and mercury oxide will not melt or boil below 1500° C.

Mercury melts at −38° C. and boils at 357° C.

Silver melts at 961° C. and boils at 1955° C.

Water melts at 0° C. and boils at 100° C.

Part II (40 Credits)

1. Will zinc replace hydrogen?
2. Will mercury replace hydrogen?
3. Will copper replace zinc?
4. Will copper replace silver?
5. Will antimony replace hydrogen?

Observing the following conventions as to physical states of matter,

(1) A line under the formula if a solid or insoluble substance. Example $\underline{Cu}$.

(2) A line above the formula if a gas. Example $\overline{H_2}$.

(3) Formula only if a liquid. Example H_2O.

(4) (aq) placed after the formula if a solution. Example NaCl (aq),

you are to indicate the physical state of each substance under the conditions given in the following equations which are balanced and otherwise correctly written.

6. $AgNO_3 + NaCl \longrightarrow NaNO_3 + AgCl$ (All four substances are in water).
7. $BaCl_2 + K_2SO_4 \longrightarrow BaSO_4 + 2KCl$ (all four substances are in water).

8. $2Zn + O_2 \longrightarrow 2ZnO$ (all at a temperature of 1100° C).

9. $2HgO + \text{heat} \longrightarrow 2Hg + O_2$ (all at a temperature of 1100° C).

10. Which metal oxides of the electrochemical series would lose all of their oxygen at the temperature of the Bunsen burner?

11. Fill in the chart indicating whether the following substances will be solid, liquid or gaseous at the temperature indicated: Example: water at 1500° C. is a gas.

	—10° C.	20° C.	1500° C.
Water			Gas
Mercury			
Silver			

12. Sodium hydroxide and silica react together to form sodium silicate which is commercially known as water glass. Sodium hydroxide does not react with carbon. Melted sodium hydroxide attacks platinum. Porcelain crucibles contain a large percentage of silica and graphite crucibles are chiefly carbon. Crucibles are also made of iron, nickel, platinum, and other metals. If you were given a solid stick of sodium hydroxide and a choice of a graphite, porcelain, and platinum crucible, which would you select in which to melt the sodium hydroxide?

13. If you were given a solution which contained sodium fluoride and hydrochloric acid, how could you prepare an insoluble fluoride?

Part III (5 Credits)

1. Charles' law states that if the pressure is kept constant, the volume of a gas varies directly as the absolute temperature. (The absolute temperature is 273° higher than the Centigrade temperature. Example: 20° C. is 293° absolute.)

If a certain amount of gas occupies a volume of 6.6 cubic centimeters at 57° C., what volume will it occupy at 27° C.?

2. Boyle's law states that if the temperature is kept fixed but the pressure varied that the volume of a gas will vary inversely as the pressure applied.

If a certain gas occupies 40.4 cubic centimeters at 5 atmospheres pressure, what volume will it occupy at 8.08 atmospheres?

3. A sample of zinc ore was found by analysis to be 90.2% zinc sulfide, how many pounds of zinc sulfide could be obtained from 1.06 tons of the ore?

4. Calcium carbonate is 40% calcium. How many grams of calcium carbonate could be obtained from 16.648 grams of calcium?

5. Sulfuric acid is 32.6% sulfur; pure zinc sulfide is 32.8% sulfur. But the zinc sulfide ore available is only 90.2% pure. How many tons of sulfuric acid could be prepared from ten tons of the zinc sulfide ore?

The class was allowed fifty minutes to answer this examination. Section III contained more problems than the best students could complete in the allowed time and was placed last for a two-fold reason: we wanted no one to finish the examination and we wanted each one to answer Sections I and II to the limit of his ability. For this reason, Section III was partially a speed test; undoubtedly the average grade would have been higher had more time been allowed. The letter grades of this examination were given by assigning the highest ten per cent A; the next fifteen, B; the next fifty, C; the next fifteen, D; and the lowest ten per cent F.

The semester grade is the composite of: laboratory, one-fourth; monthly and final examinations, one-fourth; and daily recitations, one-half. The recitation grade is based on ten-minute written quizzes given at every class meeting. The letter-grade distribution for the semester ending January, 1927, was: 7.8% A, 18% B, 45.3% C, 13.4% D, 15.2% F. The letter grade distribution for the semester ending June, 1927, was: 10.4% A, 21.8% B, 30% C, 26% D, 11.4% F.

TABLE I

COMPARISON BETWEEN PLACEMENT EXAMINATION GRADES AND SEMESTER GRADES

Letter grade of the placement examination given Sept., 1926	Semester grade in chemistry 1st semester—January, 1927					No. of students
A	2A	8B	9C	2D	0F	21
B	3A	9B	14C	4D	1F	31
C	12A	18B	55C	15D	8F	108
D	0A	4B	14C	3D	15F	36
F	0A	0B	4C	5D	8F	17
						213

	Did not register 2nd semester	Semester grade in chemistry 2nd semester—June, 1927					Failed 1st sem.	No. of students
A	3	3A	8B	5C	2D	0F	0	21
B	5	5A	4B	6C	8D	2F	1	31
C	7	7A	25B	30C	20D	11F	8	108
D	1	1A	2B	10C	5D	2F	15	36
F	0	0A	0B	2C	3D	4F	8	17
								213

Table I shows the relation between the grades on the above examination and the grades in chemistry for each semester. These conclusions may be drawn from the table:

(1) Of the 52 who were in the top quarter in the placement examination in September, only one failed the course in January and two more failed in June; *i. e.*, only three people or 5% of this group failed during the year.

(2) Of the 53 who were in the lowest quarter in the September placement examination, 23 failed in January and 6 more failed in June, or 55% of this group failed during the year. In this same group, no one made an A the first semester and only one made A the second semester; *i. e.*, only 1.8% of this group made A during the year.

(3) 66% of the A's in the course in January came from the group which constituted the middle fifty per cent in the September placement examination.

In the light of these conclusions, we would have been justified in placing

those students who were in the lowest quarter in the September examinations in poor sections. This examination would have been a fair test to sift out the F students, although it would not have located the A students of the course.

We sought the relation between high-school grades and grades in college chemistry by comparing separately the high-school grades in (*a*) chemistry, (*b*) elementary algebra, (*c*) intermediate algebra, (*d*) plane geometry, (*e*) solid geometry, (*f*) trigonometry with the semester grade in chemistry for each individual student. Most of the high-school grades were from New York State Regents' examinations, which have a passing grade of 65. We found that, in general, those students who rated below 80% in any of the above subjects did distinctly poorer work in chemistry than those above 80%. However, as an individual student may have made more than 80% in one of these subjects and less than 80% in another, some of the results were conflicting.

TABLE II

CORRELATION BETWEEN HIGH-SCHOOL GRADES IN CHEMISTRY AND MATHEMATICS AND COLLEGE GRADES IN CHEMISTRY

Classified as to high-school grades in chemistry and mathematics presented for entrance		Semester grade in chemistry 1st semester—January, 1927					No. of students
All "High"		9A	8B	7C	2D	0F	26
"Medium"	Chem. "High" Part of Math. "High"	3A	10B	21C	5D	6F	45
	Chem. "Low" Part of Math. "High"	3A	11B	35C	9D	3F	61
All "Low"		1A	4B	17C	11D	19F	52
							184

		Did not register 2nd semester	Semester grade in chemistry 2nd semester—June, 1927					Failed 1st semester	No. of students
All "High"		4	8A	6B	5C	3D	0F	0	26
"Medium"	Chem. "High" Part of Math. "High"	3	4A	15B	12C	4D	1F	6	45
	Chem. "Low" Part of Math. "High"	7	2A	9B	17C	15D	8F	3	61
All "Low"		2	2A	2B	10C	11D	6F	19	52
									184

Next we sought correlation between all of the high-school grades in mathematics and chemistry and the semester grade in chemistry. The results are recorded in Table II.

All "High"—Those who rated 80% or higher in high-school chemistry and in all of the mathematics courses presented for entrance credit.

Chemistry "High" and part of mathematics "High"—Those who made 80% or higher in high-school chemistry and who made 80% or higher in one or more courses in mathematics presented for entrance.

Chemistry "Low" and part of mathematics "High"—Those who made below 80% in high-school chemistry but 80% or higher in one or more courses in mathematics presented for entrance.

All "Low"—Those who made less than 80% in high-school chemistry and in all of mathematics courses presented for entrance.

Table II shows the relation between the grades of these four groups in high-school work and the grades in college chemistry for each semester. Certain conclusions may be drawn from this table:

1. Of the 26 who were all "High," not one failed either of the semesters. Approximately one-third of this group made A in January. Approximately one-third of this group made A in June. From this group came 50% of the A's made in the course in January. From this group came 42% of the A's made in the course in June.

TABLE III

CORRELATION BETWEEN HIGH-SCHOOL AND COLLEGE GRADES IN CHEMISTRY

Classified as to grade in high-school chemistry (math. not considered)	Semester grade in chemistry 1st semester—January, 1927						No. of students
"High" in high-school chemistry (80 or above)	14A	20B	37C	8D	8F	3 drop	90
"Low" in high-school chemistry (below 80)	4A	18B	60C	21D	21F	4 drop	128
							218

	Did not register 2nd semester	Semester grade in chemistry 2nd semester—June, 1927.					Failed 1st semester	No. of students
"High" in high-school chemistry (80 or above)	10	13A	24B	25C	8D	2F	8	90
"Low" in high-school chemistry (below 80)	13	4A	14B	30C	30D	16F	21	128
								218

2. Of the 52 who were all "Low," only one made A in January and two made A in June. Of the 52, 19 failed in January and 6 more in June; *i. e.*, 48% of this group failed either in January or in June. 60% of the

F's of the course in January came from this group. 28% of the F's of the course in June came from this group.

3. Taking the other two groups of this classification, the January results do not indicate much difference between the "High" in high-school chemistry and the "Low," but the June results show that those who were "High" in high-school chemistry have done definitely better.

This classification from high-school grades would have served fairly well to predict the success in college chemistry. Conclusion 3 raised the question as to the value of classifying the entering students as "High" in high-school chemistry (80 or above) and "Low" in high-school chemistry (less than 80). This question is answered in Table III.

From Table III may be drawn these conclusions:

1. 15% of the group which was "High" in high-school chemistry made A in January. The same per cent made A in June. 11% of this group flunked either the first or second semester. 77% of the A's of the course in January came from this group. 68% of the A's of the course in June came from this group. 24% of the F's of the course came from this group in January. 9% of the F's of the course came from this group in June.

2. Of the group which was "Low" in high-school chemistry, 3% made A in January and 3% made A in June. 28% of this group made F during the year. 63% of the F's of the course in January came from this group. 76% of the F's of the course in June came from this group.

The results in Table I and Table II suggest a program which we plan to follow in sectioning in September, 1927. From the entrance grades in high-school chemistry and mathematics, those students who will take the general chemistry course will be classified under the three headings: All "High," All "Low," "Medium." The "Medium" group will then include all those who were neither above 80% in all of the high-school subjects considered nor were they below 80% in all. This classification can be completed before registration and the "High" group placed in good sections and the "Low" group in poor sections as they register. At the first lecture session, a placement examination will be given, the results of which will probably warrant a few additional changes.

The results of 1926 indicate it would have been wise to shift out of the poor section those who were in the top quarter in the September placement examination and to shift out of the good sections into poor ones all who were in the lowest quarter. The "Medium" group will always include potentially good students. But any of this "Medium" group, who rate in the lowest quarter in the September examination, should be placed in poor sections. Had we followed the program outlined last September, we would have originally placed in poor sections 70% of the students who finally failed the first semester's work. With the

exception of one student, we would have placed our A students in good sections or in medium ones—which are potentially good ones. It is of interest to note that of the group which was "Low" in high-school chemistry and in all of the mathematics courses, 22 were also in the lowest quarter in the September examination. Of the 22, 16 failed first semester and 2 more the second semester.

The results of Table I and III suggest another program for sectioning. All who made 80% or more in high-school chemistry might be classified as "High" in chemistry and registered in good sections; those who made less than 80% in high-school chemistry as "Low" in chemistry and registered in poor sections. At the first lecture session, a placement examination should be given as a basis for such shifts as seem warranted before assigning lockers. From the "Low" group, those students who were in the lowest quarter in the September examination should be assigned to poor sections. In the same section should be placed any who were "High" in high-school chemistry but were also in the lowest quarter in the September examination. Had we followed this plan in September, 1926, we would have placed in the poor sections 60% of the F's of the course for the first semester. There were 52 such people and the first semester record of the 52 is: 0 A, 4 B, 19 C, 7 D, 20 F and 2 drops.

The latter method of sectioning requires less information concerning the high-school records of individual students and evidently serves fairly well in prediction. By the former method, we could have grouped most of the flunkers in one section and about half of the A students together in another section. By such sectioning, it is possible to cater to the special needs of each group without being unfair to either the good or the poor student.

We can see no reason why this method of sectioning could not be extended to a group which had never had chemistry. Grades in high-school mathematics serve as a fairly good means of predicting of success in college chemistry. As students who do not present chemistry for entrance usually do present physics, the high-school grade in physics ought to be of value. We are working on those data at the present time. The group could be first classified by their high-school grades in physics and mathematics. A modified placement examination could be given them at the first lecture session as an early indication of the adaptability of these students to a "chemical environment."

We are preparing another placement test for this fall which will be of the same nature as the one of last year but which will include more questions. We are also preparing a test for the group which has never had chemistry.

I wish to express my appreciation to Dr. R. A. Baker for his interest and advice in the gathering of the data and the preparation of this paper.

A LABORATORY EXAMINATION IN FIRST-YEAR COLLEGE CHEMISTRY*

JOHN R. LEWIS, UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN

A first-year course in general chemistry should be planned with the purpose of teaching students some of the simple, fundamental concepts of the science. To attain this end, students must not only learn a great many facts, but they must also understand the principles, without which the course would be of questionable value. Many of these may be acquired with the help of the lectures and class discussions; since, however, chemistry is an experimental science, the laboratory is the best place to acquire, through experimentation, the important information that is so essential to a comprehensive understanding of the subject, and it is the only place where laboratory technic can be acquired. In addition the laboratory is a workshop where students are obliged to make use of this knowledge in the solution of problems.

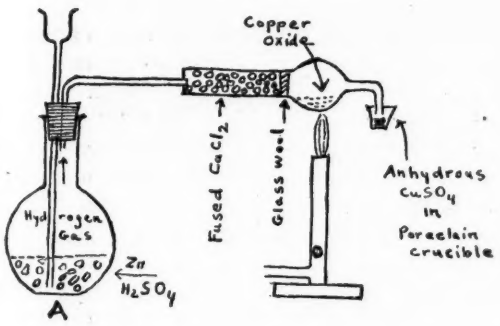
The progress and abilities of students taking general chemistry are usually determined by means of written examinations. Although such tests enable the instructor to ascertain rather accurately a student's knowledge of chemical facts and principles, they give little or no information about the student's laboratory ability. In a majority of cases those students who do well in written examinations also excel in the laboratory. It does not necessarily follow, however, that such is always the case; for students may "cram" for a written examination and pass and yet be incapable of doing the laboratory work intelligently. Or again, students may be especially adapted for laboratory work but do poorly in written tests. It is true that instructors are able in many cases, through observation and through correcting laboratory notebooks, to classify their students rather accurately. Frequently, however, the instructor confuses faithfulness in following directions and neatness in writing notes (which are desirable) with real laboratory ability. That ability to do experimental work is as essential as the ability to write examinations has been recognized for many years. In describing the examinations in elementary physics given at Harvard, Professor N. H. Black[1] says, "Let me briefly describe the laboratory examination in physics which has been conducted in Cambridge in June and September for more than thirty years. They count equally with the written examinations for admission to Harvard College. But just what is such an examination? Briefly it consists in having each student perform three

* Paper read before the Mid-West Regional Meeting of the American Chemical Society, held in Chicago, Ill., May 27 and 28, 1927.

[1] "Some New and Old Types of Physics Tests," *Sch. Sci. Math.*, **26**, 272–4 (March, 1926).

Object of Experiment:

To show that copper oxide contains Oxygen.



Apparatus and Materials:

The above diagram shows all materials used.

Method and Observations:

Hydrogen generated in A was dried in the Calcium chloride tube before passing over the hot copper oxide. Reaction between the hydrogen and copper oxide produced water, as shown by the following equation:

$$CuO + H_2 + heat \rightarrow Cu + H_2O$$

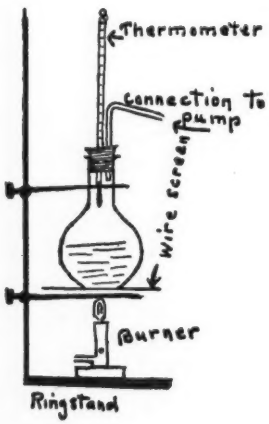
The vapor formed was proved to be water because it caused anhydrous copper sulfate to turn blue. Since water is known to contain oxygen, and since the water formed came from the action of Hydrogen on copper oxide, we may conclude that copper oxide contains oxygen.

By Paul Purcell

FIG. 1.—THIS IS A COPY OF ONE OF THE REPORTS HANDED IN BY A STUDENT. THE APPARATUS USED IN THIS SET-UP WAS REGULAR EQUIPMENT IN THE STUDENT'S LOCKER. MOST STUDENTS KNOW THE SEPARATE FACTS NECESSARY FOR THE SOLUTION OF THIS PROBLEM, BUT FEW ARE ABLE TO USE THEM AS WELL AS IN THIS PARTICULAR CASE

or four experiments which he has already done in his school laboratory in the course of the year. When he has finished an experiment, he is quizzed about his work, his calculations, his equations and about the

significance of his results. Usually the candidate is questioned by three or four different teachers, each of whom records in code his estimate of the student's ability, not only to do physical experiments, but also



Object of Experiment:
To show that the boiling point of water depends on the pressure

Apparatus:
1, Ringstand (2) Wire screen (3) thermometer (4) Two-holed rubber stopper (5) Bunsen burner (6) rubber tubing (7) Vacuum pump (8) Flask (9) ring stand etc.

Materials:
Distilled water

Observations:
The water was heated until it boiled and then the thermometer read 98.5°C. The flask was partially evacuated and the water then boiled at 70°C. The pressure was again decreased and the water boiled at 50°C. The next trial the pressure was decreased as low as is possible with the pump used and the water boiled at 34°C. After restoring normal pressure water boiled at 98.5

Discussion:
This experiment proves that the boiling point of water depends on the pressure.

FIG. 2.—THIS FIGURE ILLUSTRATES THE SOLUTION OF ONE OF THE SIMPLER PROBLEMS. IT SHOWS, HOWEVER, THAT THE STUDENT HAD A CLEAR UNDERSTANDING OF THE PRINCIPLES INVOLVED

to think about physical phenomena. This last year we conducted these laboratory examinations every day for two weeks in June and one week in September, and the whole staff of the Physics Department took part. Such examinations are of great value in helping the student review his experimental work." It is interesting to know that students who offer

chemistry at Harvard also have to pass a laboratory examination patterned after their physics test.

In searching for a suitable method of determining students' aptness for laboratory work in general chemistry, the laboratory examination described in this paper was tried. It was felt that such a test would supplement the regular written examination by furnishing more information about the abilities of students to solve problems of an experimental nature. This type of examination has been given at this university several times; first to a group of twenty students, next to a group of eighty, and twice later to some seven hundred students.

The Test

The problems used were of the "thought type," selected from a large number suggested by staff members. They were chosen with the purpose of applying to an actual problem the principles and methods of manipulation learned in conventional experiments. From a large number of problems, the instructors in charge of the laboratory sections selected the ones especially suited to the needs of the individual student. This choice was based largely on his previous record; a student with a good record receiving the most difficult problems. The students were given their assignments on long sheets of paper containing a few general instructions written at the top of the page, the remainder and the reverse side of the sheet being used for the reports which consisted of: (1) a brief statement of the problem; (2) a list of the materials used; (3) a description of the method chosen; (4) observations, equations, and the discussion. In case a student could not do the assigned problem he had the privilege of asking for another. In some instances students were given two problems with the privilege of choosing one. There was no apparent advantage in following the latter procedure. Many included drawings of their apparatus although these were not required. The regular laboratory period (two hours) used for this test proved ample time for students to do the experimental work and write their reports.

During the examination the instructor in charge approved apparatus and materials and observed the students at work. This precaution was taken simply to avoid accidents, the students understanding that such approval was for that purpose only.

The papers were graded qualitatively, being divided into three classes (1) excellent and good; (2) fair and poor; (3) unsatisfactory.

The following are typical examples of the problems:

1. Prepare metallic copper from two different compounds of copper, using two distinctly different methods.

2. Starting with metallic copper, prepare copper chloride without using free chlorine.

3. Starting in each case with ammonium chloride and using necessary chemicals, prepare samples of (*a*) table salt, (*b*) ammonia, (*c*) hydrogen chloride, (*d*) ammonium nitrate.

4. Purify some water that contains table salt and ammonia. Now demonstrate that your sample of water is free from ammonia.

5. Show that iron gains weight when heated in air.

6. Show that sodium bisulfate contains replaceable hydrogen.

7. Show that ammonia is more soluble in water than air is.

8. Show that copper sulfate contains copper.

9. Show that copper oxide contains oxygen.

10. Show that ammonia contains hydrogen.

11. Prepare ammonia and hydrogen chloride from ammonium chloride.

12. Starting with sulfur, prepare a dilute sulfuric acid solution.

13. Given copper oxide, wood chips, sand and a burner, prepare metallic copper.

14. Perform an experiment to show that hydrochloric is a stronger acid than acetic acid.

15. Perform an experiment that shows that hydrogen is more diffusible and, therefore, lighter than air.

16. Perform an experiment to show (*a*) that the boiling point of water depends on the atmospheric pressure, (*b*) the effect of a dissolved non-volatile substance on the boiling point of water.

17. Starting with a dime and necessary chemicals prepare:
(*a*) silver chloride, (*b*) copper nitrate, (*c*) metallic copper, (*d*) copper hydroxide.

18. Given sodium acid sulfate and other necessary chemicals prepare:
(*a*) table salt, (*b*) sodium sulfate, (*c*) hydrogen chloride.

19. Show by two different methods that copper is less active than zinc. Show by two different methods that copper is more active than mercury.

20. Show by two different experiments that hydrogen is a constituent of water.

21. Prepare a solution of hydrochloric acid and show by three methods that it is an acid. Show that it may also act as a reducing agent.

22. Show by means of two experiments that copper is below zinc in the activity series and by two experiments that it is above mercury.

23. Show that air contains oxygen.

24. Show that ammonium chloride contains nitrogen and hydrogen.

The accompanying cuts are samples of the reports handed in by the students.

Discussion

The purpose of the laboratory examination, as stated in the introduction, was to furnish information supplementary to the regular written tests

which would enable instructors to determine the aptness of students for laboratory work. Its value for this purpose, as shown by the students' reports, has been gratifying, and in addition certain other values have been realized that will be discussed here.

(1) The laboratory examination is an excellent means of emphasizing the importance of a thorough understanding of the laboratory work. Students having been informed in advance that a laboratory examination

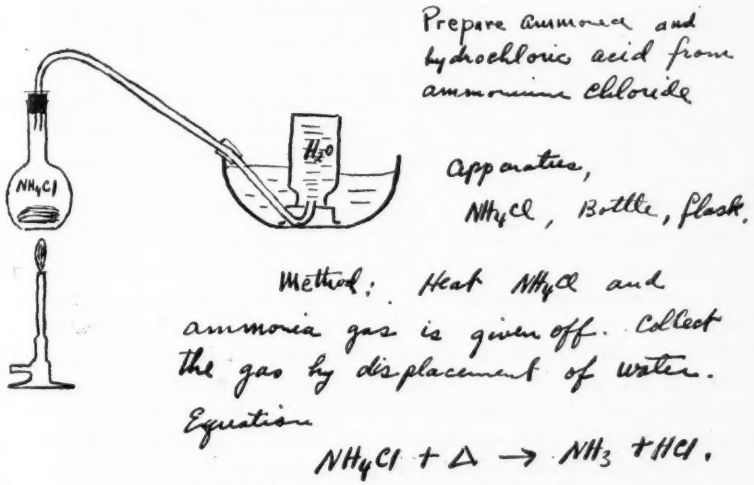

Prepare ammonia and hydrochloric acid from ammonium chloride
H_2O
NH_4Cl
Apparatus,
NH_4Cl, Bottle, flask.
Method: Heat NH_4Cl and ammonia gas is given off. Collect the gas by displacement of water.
Equation
$NH_4Cl + \Delta \rightarrow NH_3 + HCl$.

FIG. 3.—THIS REPORT SHOWS THAT THE STUDENT WAS ENTIRELY UNPREPARED FOR THIS PROBLEM

was to be given, in which they were to apply the facts and principles they had learned in solving problems, reviewed thoroughly, trying in each case to remember the important facts and understand the underlying principles of the experiments. Thus students were encouraged to look upon laboratory work, not as a series of unrelated exercises, but rather as a group of carefully arranged experiments, given to illustrate methods and principles that are essential to a comprehensive understanding of the subject.

(2) The laboratory examination problem is chosen for each student, the choice being based on the student's ability as revealed by written examinations, quizzes, and laboratory observations; simple problems for weak students and more difficult problems for students above average ability. In written examinations, on the other hand, questions are selected to meet the needs of all students in the course taken as a group. Consequently, all students must answer the same questions, regardless

of their varying degrees of ability. Usually the questions are too difficult for the weaker students and too simple for those of exceptional ability.

(3) The laboratory examination is more inclusive than a written test because it requires both experimental and written work. The choice, building, assembling of apparatus, and the performing of the experiment are as important as the written reports, which include information such as equations and descriptions and discussions that are usually called for in written tests.

(4) Renewed interest in chemistry comes from the satisfaction the student receives from successfully meeting the challenge of a problem that taxes his information and resourcefulness. The interest taken by students in qualitative analysis is due largely to the challenge each unknown brings to the student. Likewise, the student's interest in general chemistry is aroused by meeting the challenge of a laboratory examination.

(5) The most important value of a laboratory examination is the fact that the students are confronted with definite problems. Naturally they will make use of the information they have learned, and in addition they must conceive a feasible method by which the desired results can be obtained. It is under such circumstances that students leave the beaten path of following directions, and strike out into a path of their own making. It is interesting to note in passing that ingenious methods, many impractical but others possessing merit, are developed by the students, showing that through the laboratory examination they have been stimulated to independent thinking and creative work.

The author wishes to thank Professor J. H. Walton and Professor F. C. Krauskopf of this department for valuable suggestions, and for their interest in this examination.

Teachers are invited to give this examination a trial. Suggestions and criticisms will be appreciated.

Swiss Scientific Society Held 108th Meeting. The 108th annual meeting of the Swiss Society of Natural Sciences was held in Basel, September 1st–4th. Addresses were made in the fourteen different sections by outstanding scientists from leading universities of Europe.—*Science Service*

Related Students Grade Alike. Good marks in school "run in families," if the grades of a hundred brothers and sisters in the University of Oregon are any testimony.

The records of related students selected from the period since 1919 were examined by Dr. R. R. Huestis, assistant professor of genetics, and T. P. Otto to test the principle that individuals of the same heredity brought up in the same environment react in the same way.

Brothers showed greater divergence than sisters while the girls had consistently higher grades than the boys, Dr. Huestis declared in a report of the test to the *Journal of Heredity*.—*Science Service*

INDUSTRIAL CHEMISTRY BY THE UNIT PLANT METHOD*

C. L. MANTELL AND ALLEN ROGERS, CHEMICAL INDUSTRIES LABORATORIES, PRATT INSTITUTE, BROOKLYN, NEW YORK

In the recent report of the Committee of the Society for the Promotion of Engineering Education, appointed to study engineering education in the United States, the need for chemical training for foremanship in the growing chemical industries was emphasized. Pratt Institute has for a score of years been devoting its energies to giving engineering education of the non-collegiate type. The Department of Industrial Chemical Engineering does not produce designing chemical engineers, factory managers or research chemists; but does produce graduates who become industrial chemists, engineering inspectors, department foremen, technical assistants, chemical salesmen, and to a limited extent, analysts, assayers, and assistant chemists. The graduates of the two-year intensive course become the trained plant operatives of industrial organizations.

Most of our students have had a number of years of industrial experience before entering their training; this industrial experience in a sense is a prerequisite for entrance. They are all of a decidedly practical bent. Their courses of training must be adapted to them.

This paper concerns itself particularly with one of the component parts of the two-year course in industrial chemical engineering. The division is that of industrial chemistry. The average college is poorly or not at all equipped in this particular field. The same is true to a lesser extent in our engineering schools of the country. Only in the outstanding schools do we find good and semi-commercial size equipment for teaching industrial chemistry.

There are two general methods of instruction—one the unit process and the other the unit plant. In the first the unit chemical engineering processes—evaporation, filtration, distillation, etc., are given attention; in the other the unit plant and its products are specifically studied. The second method is adapted to our work at Pratt Institute.

The equipment of the laboratory is in the form of unit plants set up as such with large amounts of individual equipment capable of assembly into semi-commercial plants. For example, the soap unit, capable of producing any kind of commercial soap, consists of a lye tank, boiling tank, crutcher, wire cutter, slabber, soap mill, drier, plodder and cake stamping machine. A batch is 500 cakes of soap produced in a commercially finished shape, wrapped and ready for delivery. The paint plant, consisting of paste mixers, burr stone mills, pebble mills and thinning mixers produces ten gallons of finished paint as a minimum batch.

* A paper read before the Division of Chemical Education of the American Chemical Society, Richmond, Va., April 13, 1927.

The tannery is exceedingly well equipped. As one student remarked, it is almost possible to walk in a cow on the hoof and walk out with the finished leather on your own hoof. The tannery is almost an industrial unit. The same holds true for the electroplating plant, the fine chemicals station and dyeing plant and the dye testing unit, the ink and pigment plant and the distillation, drying, and hydraulic equipment. Other machines such as furnaces, filters and filter presses, pumps, vacuum machinery, grinding equipment, for special uses, are of semi-commercial size.

The instruction in the course of industrial chemistry is given from the unit plant viewpoint. The men operate the various plants in groups under one of their number acting as foreman, making the commercial substances on their own responsibility (of course, under instructor's supervision), produce standard quality products and dispose of the same to commercial consumers. In this manner they operate practical machinery, work on a commercial scale and learn chemical engineering unit processes indirectly, but acquiring commercial acquaintance with the manufacture of chemical products.

The Chemical Industries Laboratories at Pratt Institute in operation have been a show place for visitors for many years. Its success as a teaching unit, as part of the work in industrial chemical engineering courses, is attested by the commercial success of its now 700 graduates. The arrangement of the laboratories, the layout of the equipment, the selection and operation of the equipment have proved a successful way of training men for foremanship in the chemical and allied industries.

STUDENTS' COURSE, ELEVENTH EXPOSITION OF CHEMICAL INDUSTRIES

Monday—September 26th

12.00 to 3.00 P.M.: *Registration.* At the Information Desk in the Chemical Exposition in Grand Central Palace. This Desk is just inside the main entrance and to the right. Registration Cards will there be authenticated.

3.00 P.M. Addresses: "Welcome to Exposition," by Charles F. Roth, Manager. "The Organizations of Chemists and Chemical Engineers," by T. B. Wagner, President, The Chemists' Club. Announcements, Discussion of the Course and Division of the Student Body into Sections, by W. T. Read, Chairman of the Course.

Tuesday—September 27th

9.00 A.M. General Lecture: "Ethics and Ideals of the Chemical Profession," by Arthur D. Little, President, A. D. Little, Inc.

9.30 A.M.: Separation of the Student Body into two groups:

GROUP I

This group will comprise students who have knowledge of elementary chemistry:

DISINTEGRATION: Crushing, Grinding, and Grading—Chas. E. Locke, Massachusetts Institute of Technology.

MECHANICAL SEPARATION: Separation of Solids from Liquids; Filtration, Grading, Classifying, Settling and Thickening—Arthur Wright, Filtration Engineers, Inc., New York.

REVIEW AND DISCUSSION:

2.00 to 3.00 P.M.: Group Conference between students of this group and Exhibitors' Representatives especially invited to reply to questions about the apparatus discussed in the above program.

3.00 to 5.00 P.M.: Group Inspections of exhibits in charge of designated guides.

GROUP II

This group will comprise advanced students and those having a more extensive knowledge of chemistry and chemical engineering:

DISINTEGRATION: Crushing, Grinding and Grading—S. B. Kanowitz, Raymond Bros. Impact Pulv. Co., New York.

MECHANICAL SEPARATION: Filtration—E. J. Sweetland, United Filters Corp., New York.

2.00 P.M. and Thereafter: Individual study by students of exhibits in particular subjects of research or upon the topics assigned by his own College Instructor or the Chairman of the Course. This study to include review of the latest literature on the subjects in publishers' booths, exhaustive study of all the displays of the subject and detailed study of each. Thereafter general study of all exhibits in preparation for the Report and Discussion on Saturday.

Wednesday—September 28th

9.00 A.M. General Lecture: "What the Chemist and Engineer Read," by H. C. Parmelee, Editor, *Chemical & Metallurgical Engineering.*

9.30 A.M.: Separation of the Student Body into two groups:

GROUP I

MECHANICAL SEPARATION: Thickening and Sedimentation—A. Anable, The Dorr Company, New York.

Centrifugals and Centrifuges—Arthur W. Hixson, Columbia University.

Dust Collectors—speaker to be announced.

HANDLING OF MATERIALS: Vertical, Lateral and Horizontal Transportation—A. E. Marshall, Corning Glass Works, New York.

REVIEW AND DISCUSSION:

2.00 to 5.00 P.M.: Group Conference and Inspections—see program for Tuesday.

GROUP II

MECHANICAL SEPARATION: Centrifugals and Centrifuges—speaker to be announced.

Dust Collectors—Harlowe Hardinge, Hardinge Co., New York.

Electrical Precipitation—P. E. Landolt, Western Precipitation Co., New York.

HANDLING OF MATERIALS: Conveying with Currents of Air—Wm. B. Spooner, C. S. Hallowell, Inc., New York.

2.00 P.M. and Thereafter: Individual and General Study—see program for Tuesday.

Thursday—September 29th

9.00 A.M. General Lecture: "How the Products the Chemist Makes Are Sold," by Williams Haynes, Publisher, *Chemical Markets.*

9.30 A.M. "Reading the Thermometers of the Chemistry of Business," by Edwin E. Judd, Editor, *Industrial Digest.*

10.00 A.M.: Separation of the Student Body into two groups:

GROUP I

SEPARATION WITH PHASE CHANGE: Evaporation, Distillation and Drying: Theory—W. A. McAdams, Massachusetts Institute of Technology.

Practice: Construction and Operation of Apparatus—speaker to be announced.

Drying: G. W. O'Keefe, Filtration Engineers, Inc., New York.

REVIEW AND DISCUSSION:

2.00 to 5.00 P.M.: Group Conference and Inspections—see program for Tuesday.

GROUP II

SEPARATION WITH PHASE CHANGE: Thermodynamics and Mechanics Applied to the Fundamental Problems of Distillation, Evaporation, and Drying—speaker to be announced.

Practice: The Operation of Evaporators—speaker to be announced.

Drying: J. H. Nair, Merrill Soule Co., Syracuse, N. Y.

WEIGHING AND MEASURING: speaker to be announced.

2.00 P.M. and Thereafter: Individual and General Study—see program for Tuesday.

Friday—September 30th

9.00 A.M. General Lecture: "What the Chemist and Engineer Write," by H. E. Howe, Editor, *Industrial & Engineering Chemistry.*

9.45 A.M.: "Safety in the Laboratory and the Plant," by G. Edwin White, College of the City of New York.

10.00 A.M. Separation of the Student Body into two groups:

GROUP I

MATERIALS OF CONSTRUCTION: What to use, when, where, and why.

Ceramic Materials to Use in Chemical Plant Construction—Ross C. Purdy, Sec'y American Ceramic Society, Columbus, Ohio.

Metals, Alloys, Plastics, Wood, Fibers, and Fabrics as Materials of Construction—W. S. Calcott, E. I. du Pont de Nemours & Co., Wilmington, Delaware.

REVIEW AND DISCUSSION:

2.00 to 5.00 P.M.: Group Conference and Inspections—see program for Tuesday.

GROUP II

MATERIALS OF CONSTRUCTION: Ferrous Metals and Alloys—speaker to be announced.

Non-Ferrous Metals and Alloys—speaker to be announced.

Silica and Silicate Materials: Glass—A. E. Marshall, Corning Glass Works, New York.

2.00 P.M. and Thereafter: Individual and General Study—see program for Tuesday.

Saturday—October 1st

9.00 A.M. General Lecture: "What the Exposition Shows Us That the Chemist and Chemical Engineer Have Accomplished," by H. E. Howe, Editor, *Industrial & Engineering Chemistry.*

After this lecture the Student Body will separate into two groups for purposes as follows:

GROUP I	*GROUP II*
General Review: Statement by Chairman of the type of report desired and issuing of printed questions. Students to make use of all available sources of information and to illustrate replies with drawings when necessary.	Oral statements from reports prepared by the individual students on topics which they selected at the beginning of the course and discussion thereon by the group.

Minute Doses of Iodine Speed Blood Circulation. More accurate knowledge of means of combating hardening of the arteries and other circulatory troubles of old age is the objective of experiments recently performed on the hearts of cats, kept alive after their removal from their departed owners' bodies. Dr. Hans Guggenheim, noted Berlin physiologist, reports that exceedingly minute doses of iodine have important effects on the circulation, as measured on the coronary artery in the muscular wall of the heart.

That iodine has a speeding-up effect on the circulation has been known for some time, Dr. Guggenheim states, but doctors have not been able to get even an approximate notion of the best size for their doses. Hence his experiments. He found that the coronary arteries of his isolated cat hearts would dilate under the influence of potassium iodide at a concentration of one part in a hundred thousand, and that this dilation could be maintained at a dilution as great as one part in five million. Iodine doses for arteriosclerosis have hitherto usually been much higher than this, he states, but if clinical experience bears out the conclusions derived from his experimental work, it will be possible to reduce the medical dose to a much smaller size.—*Science Service*

Gland Extract Helps Near-Sightedness. Epinephrin, the drug that is extracted from the suprarenal glands, may be a remedy for near-sightedness. Dr. Meyer Wiener of St. Louis has tried out minute quantities of the powerful drug on patients with progressive myopia, and in a preliminary report of his results to the American Medical Association states his belief in its value in correcting this derangement of vision.

Medical opinion as to the cause of myopia is divided. It is thought to be hereditary within certain limits. Application to close work has also long been blamed as a cause of the failure of the eyes in its progressive phase. Most physicians agree that the stretching of the outer layer of the eyeball is an important factor, but just how this comes about is still a mystery.

Exercise and diet, it is generally agreed, help as much as anything. The ranch life of Theodore Roosevelt is a classic example of what fresh air and out-of-door work will do to help bad eyes as well as the physique generally. It has been proved that exercise increases the epinephrin output of the suprarenal glands, and it is to this factor that Dr. Wiener attributes the improvement that short-sighted people gain from physical exertion.—*Science Service*

Correspondence

AN EXPERIMENT IN TEACHING PRACTICAL CHEMISTRY

The Near East, especially Greece, suffers from a lack of scientific knowledge. The public school, that is, the gymnasium, presents to its students a rather poor course in chemistry. In Salonica, the second largest city of Greece, chemistry and physics are taught by the reading method; both the physics and chemistry being contained in the same book, with chemistry the lesser and second half of the book. Only the common elements and their common compounds are mentioned. Few and antiquated illustrations are shown. Little or no laboratory work of any type is offered. Only physics laboratories exist and these in French schools. As a result students leaving the public schools have no knowledge of chemistry or its branches and are, therefore, ready to choose their life work only along commercial lines. In fact Greece actually suffers from a lack of skilled native-trained men. The greater majority of chemists and electricians and other experts come from foreign countries. Large industries are in the hands of foreign-trained men. This presents a difficult financial problem to the Greek Government.

Those connected with the Department of Science of the American College of Salonica, after studying the existing conditions, decided to add a course of practical chemistry to the curriculum. This course will be given to the highest class, which corresponds closely to the highest class of an American junior college. The course as drawn up has been adapted to meet the needs of the country. There will be no particular textbook used throughout the course, although each student will be required to purchase a copy of a good "General Chemistry." It is hoped that the student will retain this book and that later on when he has left the school he will use it as a reference book. The laboratory shelves devoted to reference books will be open to students at all times. The publications of the American Chemical Society will be accessible. Students will be assigned various articles appearing in the JOURNAL OF CHEMICAL EDUCATION and each article assigned will be reported to the class as a whole.

The program of study will be divided into two parts. The first part, extending over a semester period of six weeks, will cover the common elements and their properties, accompanied by lecture-table demonstrations with students doing the actual work under close supervision. In this way the students will learn the names and adaptations of chemicals and apparatus.

The second part, covering the remainder of the year, that is, thirty weeks, each week with three recitation periods of two hour's duration, will be devoted to laboratory work in practical chemistry. It will not be the aim of the course to acquaint the students with a mass of theoretical chemistry, but instead to show the relationship between everyday life and chemistry.

The practical side of the course will be extended also to fulfil a program of American Community Service. In view of the fact that the necessities of life as sold in Salonica are far below the poorest of American grades, the many American families are finding it difficult to maintain American standards of living. The salt which is sold for table use corresponds to the salt sold in America for making ice cream. Clean, white salt is not sold because the merchants maintain that the people cannot afford to buy it. Baking-powder is almost unattainable and that which does appear on the market is useless, having stood in damp storehouses for many months. Butter is scarce, but very poor grades of oleomargerine are plentiful at tremendously high prices. Toilet soaps are entirely imported although Greece is the producer of olive oil, one of the chief requisites for making good soap. These few cases illustrate the situation, and to remedy it, the Department of Science has issued a bulletin to members of the American and English Community, suggesting that they acquaint the Chemistry Laboratory with their needs. As a result the laboratory has drawn up a program which will embody the various needs as chemical projects.

The laboratory will produce clean, white salt, the students carrying on the project from beginning to end, noting production costs, etc. They will also become acquainted with filtration and crystallization. Another project will be the making of various types of soap. The college laundry will be supplied with soap made in the chemistry laboratory. The following program gives, in brief, the general topics along which students will work:

1. Preparation of Starch
2. Purification of Salt
3. Preparation of Gluten
4. Preparation of Baking-powder
5. Examination of Foodstuffs
6. Examination of Drinking Water
7. Examination of Soils
8. Manufacture of Soaps
9. Cleaning and Dyeing
10. Simple Analytical Work.

As other subjects present themselves they will be given a place in the program.

A course in practical physics was tried out in the American College and pronounced a marked success over the ordinary course as presented in a great many high schools. Those interested in this new project of the Science Department are anticipating a successful year. The

director of the department wishes to thank the JOURNAL OF CHEMICAL EDUCATION and those who have contributed to it for the many interesting articles appearing on various types of instruction in chemistry.

American College,
Salonica, Greece

MAURICE H. BIGELOW

PATENT MEDICINES

DEAR DR. GORDON:

In the August issue of the JOURNAL OF CHEMICAL EDUCATION, which just came to my desk today, is an article on "Patent Medicines," signed by Walter O. Walker, William Jewel College, Liberty, Missouri. I am pleased to note that Dr. Walker has brought to the attention of your readers again the abuses of the "patent medicine" business, and to note his recommendation that teachers of chemistry should inform themselves of facts in each particular case.

I felt somewhat complimented that the general organization of the article, and the material presented and its sequence, bore a similarity to an illustrated talk which I have given occasionally on the subject of "Home Remedies—Claims vs. Composition." At the end of Dr. Walker's article, there is an acknowledgment to me for the initial material incorporated in this paper.

In order that no misunderstanding may arise, I would like the readers of the JOURNAL OF CHEMICAL EDUCATION to be informed that I knew nothing of this article previous to its publication. As the article contains a number of quotation marks, it might appear that certain of the statements were based on information furnished by me. Some of these statements are more sweeping than I would make, and others contain inaccuracies. The purpose of this communication, therefore, is to disclaim responsibility.

I dislike very much to have to be forced to send such a communication. Is there not a lesson to be learned, however? Would it not have been better if either the Editor of the JOURNAL OF CHEMICAL EDUCATION or Dr. Walker had referred the paper to me before making acknowledgment in print? By so doing the necessity of a communication of this kind would have been obviated, and possible errors could have been pointed out.

Yours sincerely,
PAUL NICHOLAS LEECH, Director,
A. M. A. Chemical Laboratory

Chemical Digest

ABSTRACTS

The New England Industrial Situation from the Standpoint of Modern Chemistry. GUSTAVUS J. ESSELEN, JR., AND WALTER S. FROST. *Chem. Met. Eng.*, **34**, 364 (June, 1927).—Massachusetts, Rhode Island, and Connecticut account for 86 per cent of New England manufacturing, the other three states being largely agricultural except for pulp and chemical plants in Maine and textile plants in New Hampshire. This section is not a manufacturing center because of abundance of raw materials. The chief raw materials are limestone, marble, quartz, feldspar, mica, granite, talc, and clay; also large semi-graphitic coal deposits not worked at present and an abundance of good water. A list of twenty industries each having a yearly production of over $50,000,000 is shown in a table together with a comparison of production in the United States. The important inorganic and organic chemicals required by the industries are listed with a brief description of their uses.

With an area of 2.1 per cent of the entire United States, New England has 7 per cent of the total population, 12.6 per cent of the total capital investment, it produces 11 per cent of the manufactured products, and has 29 per cent of the savings bank deposits. Over 70 per cent of the population live within 50 miles of the seaboard, thus offering cheap transportation. Most of the required raw materials that New England is adapted to produce are now being manufactured. With a supply of high-grade wood pulp and its large textile activities, it would be the logical place for the expansion of the rayon industry. D. C. L.

The New Humanism. Preface to Volume IX of Isis. GEORGE SARTON. *Isis*, **9**, 226–33 (June, 1927).—Sarton's modestly entitled "Preface" is actually an essay on the New Humanism, a plea for the belief that science is culture, that the history of science is the history of humanity, a plea for the unity of knowledge. Without such unity the busy-ness of present science is like that of a saw-mill on the edge of the forest; without such unity—a pile of saw-dust fifty years hence.

"It is hardly necessary to insist upon the applications of science; any fool can see their value. Whenever our knowledge of nature enables us to discover a new labor-saving or money-making machine, there are always enough men to appreciate it, to use and abuse it. But the New Humanists insist that however great the practical value of science, its intellectual value is much greater still. It has at least this obvious superiority, that it cannot be abused for we cannot understand too well nor love too much.

"Unity cannot be created from the outside but only from the inside. If it does not exist in the souls of men, it does not exist anywhere. Unified knowledge does not increase by juxtaposition, but only—to use a biological term—by intussusception; it cannot grow but as a living thing and this cannot happen but in a living brain—not at all in the card indexes of the organizers, nor even in the meetings of academies. I do not wish to intimate that academies and congresses serve no useful purpose. They do render considerable service, not only from the social, but even from the purely scientific point of view. They foster scientific research in many ways. They stimulate the ambition of men and bring them together; they help to provide the financial means which become more and more necessary as the cost of scientific work increases. To solve the main problems of science it is necessary to carry out extensive analyses, which involve the collaboration of a great number of scientists working in distant parts of the world, for many years and maybe for many generations. The academies and other scientific societies help to provide the administrative direction without which such complex investigations could not possibly be completed. I fully realize the extent of the contributions; my only claim is that the academies cannot compose the internal and organic unity of science, they cannot even accomplish any scientific progress. They help to do things, they cannot do them themselves. All great discoveries, all great syntheses, were conceived by single men, and even when the latter needed the collaboration of many assistants to accomplish their task, their success was essentially due to their personal efforts. External unity is a purely administrative matter, internal unity is always an individual creation." TENNEY L. DAVIS

La théories de la composition des sels et la théorie de la combustion d'après Stahl

et ses disciples. HÉLÈNE METZGER. *Isis*, **9**, 294–325 (June, 1927).—The author believes that Stahl's great contribution to chemistry consisted in his identification of the calcination of metals with the combustion of organic substances, and in his proof of the justice of this identification by showing that combustibility can be displaced and transferred from one substance to another. Thus, the combustibility of an organic substance, if transferred to sulfuric acid, converts it into sulfur, if transferred to a calx, converts it into metal. Stahl considered the transferable combustibility to be a *principle*, intangible and incapable of being isolated. TENNEY L. DAVIS

Vocational Courses and the Junior High School. D. A. WARD. *Sch. and Soc.*, **25**, 711–6 (June 18, 1927).—The value of vocational courses as a part of the school program is discussed by the author who says that Broadley conceived all education as being vocational. The junior high school covers the adolescent period of the majority of boys and girls—a period when their mental and spiritual attitudes are changing, and when every child takes on an individuality and seeks to think and act for himself. Here he also strives to locate himself in society. He is in a state of formation and subject to the influence of environment. For these and many other reasons the junior high school finds justification for its existence and various fields in which to perform its program. The first six years are devoted to the fundamental elements of an education, followed by vocational preparation and the directing of the spiritual tendencies toward the establishment of character. Organized for the purpose of guidance, the vocational education offered should not only fit an individual for a specific occupation, but assist him in finding his abilities and tendencies.

Because training in a chosen occupation has come to be vital to success in modern society, the school is organized and operated as a community enterprise, and must meet the demands made upon it by society for the comfort and happiness of its members. Contrary to a statement by a labor leader of Chicago, the junior high school does not seek to discredit labor, but rather to dignify it by giving it scholastic recognition.
K. S. H.

Adventures in Public Education. E. W. BUTTERFIELD. *Sch. and Soc.*, **25**, 583–92 (May 21, 1927).—New England seems from the first to have solved the question, "Who shall be educated?" In 1643, though systematic education was not enforced, it was considered the duty of parents to see that their children were taught to read. As a result of Horace Mann's work some years later, New England declared that every child should have the right to a common-school education, and forced attendance on the part of the children at standard elementary schools. It was soon realized that the education offered by these common schools was not sufficient and so academies sprang up everywhere. These, however, failed to meet the general need, and the rise of the public high school was a welcome movement which spread rapidly. Depending on the people for support, they were compelled to meet with their approval and naturally much interest in them was aroused.

What the future may have in store in the way of education, who shall go to college, and the type of school which will be necessary to meet the demands remains a problem for the people themselves to solve.

Reasons for the existence of colleges and the present division into pre-professional and liberal arts schools are stated. The need of a new type of college where the teaching of students will be the aim and objective is evident. They will be public, like public high schools and supported by the people, educating citizens rather than preparing individuals for universities. Minus founders, traditions, and endowments, they will be free to pursue the most suitable course. The president of such an institution would no longer search for research workers, for scholars of fame, or for those with many degrees, but rather for teachers who can teach. And so, in concluding, the author states that he believes that New England's final answer both now and in the future will be that "All those who have a desire for further acquisition of knowledge or skill" shall go to college.
K. S. H.

Who Should Go to College? J. A. COUSENS. *Sch. and Soc.*, **25**, 613–7 (May 28, 1927).—The author answers the question, "Who should go to college?" with "That depends." The question seems to involve economic and sociological conditions. It is no longer necessary for colleges to solicit college entrance applications but rather the idea of higher education has become so universally accepted in America that a way is now sought which will permit only the intellectually gifted to enter such institutions. Dr. Cousens advocates a division of the college into an upper and a lower school, and states that the entrance requirements to the lower should be broad, but those to the higher, narrow and rigid. Thus by an arrangement of this kind, an individual would have the advantages of two years of college training.

Summing up his article, Dr. Cousens states that any boy or girl, with an intelligence above the average and possessing a suitable background for higher education, should go to college. K. S. H.

The College Student. A. L. LOWELL. *Sch. and Soc.*, **25**, 617–21 (May 28, 1927).—Dr. Lowell feels that, contrary to public opinion, there are very few boys or girls who, desiring and qualified to enter college, are barred. He feels that different grades of colleges are needed and that uniform standards are not advisable. Pursuit of education is not the only reason for going to college, and what a student does in college is not an infallible test of his fitness for such an education. A good student should have no fear of entrance examinations and once within the college walls should get the right stimuli for intellectual development. The good of the group, rather than the good of the individual, must always be a standard for college procedure. K. S. H.

Charles W. Eliot. PAUL H. HANUS. *Sch. and Soc.*, **25**, 645–54 (May 28, 1927).—A memorial tribute to President Eliot's half century of leadership. The author speaks of Harvard in President Eliot's student days as a provincial college where all subjects were prescribed, and undergraduates were neither admitted to the laboratories nor required to use the library. The admittance, therefore, of young Eliot to the chemistry laboratory of Professor Josiah P. Cook was a special privilege.

After serving as tutor of mathematics in Harvard College, he was made, in 1858, assistant professor of chemistry and mathematics, and two years later took charge of the laboratories of the Lawrence Scientific School. In 1863, he severed all connection with Harvard, and deciding to devote himself to the profession of education, spent the following two years in England, France, and Germany, studying educational institutions. Declining an industrial offer at a salary of $5000, because it would have necessitated abandoning the profession he had thus far followed, he accepted a professorship of chemistry at M. I. T. at $2000, and with Prof. Storer, a few years later, published two texts in which actual experimenting replaced much theory.

While attending a meeting of the Board of Overseers, of which he was a member, Mr. Eliot was informed that the Corporation desired to elect him president of Harvard College. This resulted in much criticism and disagreement among certain of the Board members. His inaugural address was awaited with eagerness and, as was anticipated, it set forth his views vigorously and unequivocally. Despite much controversy, the influence of President Eliot's leadership not only became a stimulating influence for the upbuilding of higher education throughout this country, but it extended into secondary and elementary education. He knew the disadvantages of a prescribed curriculum and consequently strove to establish and extend the elective system. Fairness, courage, and vision were outstanding characteristics. An active member of local and national institutions, Presient Eliot was, for nearly fifty years, an outstanding progressive leader in American education, and one of the most public-spirited citizens our country has ever produced. K. S. H.

A Study of the Relative Value of Three Methods of Teaching High-School Chemistry. H. B. NASH AND M. J. W. PHILLIPS. *J. Educ. Res.*, **15**, 371 (May, 1927).—The three methods used in this research are given as the Pupil Method, the Combination Method, and the Teacher Method. These were tried upon three groups of students of nearly equal ability in the second semester of 1925. Relative ability was measured by the Miller Mental Ability Test, Form A.

The members of the group taught by the Pupil Method were allowed to study as they wished, worked experiments when they wished, felt free to do as much as they could do, and were encouraged to ask questions whenever help or advice was needed. The first pupil to complete the regular work finished near the middle of the semester; some completed only two-thirds of the regular work by the end of the semester. This method of instruction is not easy as each pupil is studying something different in a different way and the instructor must keep informed of the progress of every student and be ready to answer all types of questions.

The Combination Method used demonstration, lecture, laboratory work, and recitation—the method used by one of the writers for years. This group might be considered a control group.

Under the Instructor Method units of work were assigned from the text and the pupils were never called upon to recite. No check was made to determine whether the lessons assigned were prepared or not. The pupils did not come in contact with any experimental materials. The instructor gave demonstrations and performed experiments before the class. They were permitted to ask questions, but under no circumstances did the instructor ask questions of the class members to determine whether the demonstrations were understood. Equations and problems were worked on the

blackboard for the pupils. The instructor did all the work of the class. The pupils took notes and occasionally questioned the instructor. The method consisted of "teacher talk" with little or no "pupil-talk." The work of the semester was easily covered, and a number of special lectures and demonstrations were presented during the time remaining before the final test.

The same tests were given to the three groups. Results of the tests are shown in a table and in graphical form. It is obvious that the Instructor Group has the highest final achievement. The results indicate that, within the limits of this experiment, in acquiring information the Instructor Method of teaching high-school chemistry is superior to the Pupil Method and to the Combination Method. That there may have been information gained by the Pupil Method which the tests did not measure is true.

A comparison of the standard deviation of the gains is very suggestive; that for the Pupil Group is 18.6 while for the Instructor Group it is 9.8—almost one-half. It suggests that the Instructor Method has about the same value for all types of pupils, while the Pupil Method has a varying value depending on the type of pupil with whom it is used. When all the work is done by the instructor there is very little opportunity for the play of individual differences. In the Pupil Group there is abundant opportunity for this and hence the group becomes widely different as to achievement.

The method used in the Pupil Group is shown to be unsuited for lazy and indifferent pupils. It works well for those pupils who have power of application and are primarily interested in chemistry. The authors suggest that class-room procedure should vary with the type of pupils in the group to be taught, each group to be so selected as to be homogeneous enough for a definite method to be used. R. M. P.

The Placement of Teachers a State Function. EDITORIAL. *J. Educ. Res.*, **16**, 57–9 (June, 1927).—The fact that public education is the state's business is not questioned. It may regulate finances, control erection of buildings, define the eligibility of teachers, establish their minimum salary, and dictate their retirement. After having made laws concerning their eligibility and certification of teachers and spent millions of dollars in training them, the state might be expected to see that each person appointed to a position possessed the appropriate training.

The author cites instances where a number of teachers hold positions for which they are not legally qualified, and others where teachers, although legally qualified, are relatively unfitted for the positions they take. Investigations show that in a certain year there were thirty-one graduates of a state institution trained for a special type of service. Seventy-five teachers were appointed in the same state to this type of service. It would be supposed that all of the thirty-one would have received appointments. In reality, only one of the seventy-five available positions was filled from the thirty-one trained for the service.

Thousands of persons trained for teaching fail to become teachers because they fail to secure positions. Many college graduates have taken up service as teachers of subjects other than those for which they were trained. Those prepared to teach history have become teachers of general science; those prepared for rural schools have positions in city grades, or have become superintendents.

It is a strange commentary upon the efficiency of a state that it should provide laws and teacher-training institutions and then be indifferent to the workings of those laws and the utilization of the product of the institution. To remedy this defect the author advocates a permanent bureau of the state department to study the needs of the schools and the supply of teachers. This bureau should coördinate the appointment service of the various teacher-training institutions to the end that vacancies may be filled by those whose qualifications correspond to the positions in question. The state should invest authority somewhere for the continuous study of problems of holding a sufficient corps of well-trained teachers, at the same time giving to this authority the power to put into effect the result of its findings. R. M. P.

Possibilities of Objective Techniques in Supervision. F. B. KNIGHT. *J. Educ. Res.*, **16**, 1–15 (June, 1927).—Different types of supervision are based not only upon varying abilities and habits of the supervisors but also upon the varying theories of supervision which determine the day's work of the supervisor.

The author presents a system of steady perpetual guidance by the supervisor, and describes the objective technics that have been in use for two years in certain educational centers. To illustrate, a list of the tools to be used in objective supervision of arithmetic are given. These are: weekly inventory drills, the teacher's diagnostic record, the teacher's weekly report to the supervisor, the supervisor's control chart, the supervisor's weekly suggestion blank, diagnostic tests, remedial units, and the textbook.

The type of supervision described in this article is clear-cut and labor saving.

It facilitates the type of leadership that teachers respect. It gives the supervisor a definiteness and clarity of aim and method which gives joy to his work. R. M. P.

Interest and Ability in Educational Guidance. DOUGLAS FRYER. *J. Educ. Res.*, 16, 27–39 (June, 1927).—In this article a study of the relationship between interest and ability in educational subjects is presented. The problem of the investigation is stated as follows: (1) Is an individual's expression of educational interests predictive of ability in educational subjects? (2) Are the individual's estimates of ability in educational subjects predictive of ability in these subjects as measured by grades?

Thorndike contends that interest is highly predictive of ability. The author follows the Thorndike method, but with the addition of a request for school grades, the investigation being carried out upon two groups of college subjects in the University of Utah and upon a group in New York University.

The author finds that an individual's statement of his interest in an educational subject is not predictive of corresponding ability in that subject. But, upon the basis of findings here reported, a probability of between 5 and 20 per cent better than a pure guess is indicated for the guidance of an individual, based upon his interest, in the study of the educational subject of his greatest ability. This is the predictive value of interest for educational guidance. The evidence given indicates that interest and ability are not closely enough related to enable us to predict ability as measured by school grades from interest expressed by the student. R. M. P.

A New and Sensitive Test for Nitrates Applicable in the Presence of Nitrites. ALAN H. WARE. *Analyst*, **52**, 332 (June, 1927).—By this method small amounts of nitrates can be detected in the presence of nitrites, in fact nitrites are essential to the reaction. If 0.2 g. each of KNO_3 and $NaNO_2$ are mixed and added to a cold solution of 0.05 g. ortho cresol in 10 cc. conc. HCl in a glass mortar and stirred thoroughly, after about one minute a dichroic solution is produced, deep green to reflected light and purple-red to transmitted light. If the amount of nitrate in the sample is small the color may form only after 5 minutes. Less than 0.001 g. nitrate can be detected by this method. As little as 0.00005 g. KNO_3 can be detected by triturating 0.01 to 1 g. of the sample with 0.05 g. cresol and 0.2 g. $NaNO_2$ in a mortar for 2 minutes, and after standing 5-15 minutes adding the HCl, producing the characteristic green color. Bromides and ethyl alcohol render the test less delicate. No other known substances simulate the action of nitrates in this test. The sodium nitrite should be tested first for nitrates. D. C. L.

Surface Tension of Liquid Metals. Part 2. L. L. BIRCUMSHAW. *Phil. Mag.*, **1**, 1286–94 (June, 1927).—The surface tensions of liquid bismuth, cadmium, zinc, and antimony have been determined at different temperatures. At the same time evidence seems to show that bismuth, cadmium, and antimony are highly associated in the liqui. state. E. S. R.

Science in Japan. HERBERT E. GREGORY. *Sci. Mo.*, **24**, 507–13 (June, 1927).—This article is the result of information obtained at the Science Congress held at Tokyo, Oct. 30 to Nov. 31, 1926. Organized scientific research in Japan covers little more than half a century. This is in striking contrast to the history of scientific study in other Pacific countries, many of which have been actively engaged in scientific research since the early part of the 19th century. Although the advancement varies considerably in the different fields of science the author is inclined to believe that, considered as a whole, Japan ranks next to the United States, England, and Germany as a scientific nation. Japanese science, like that among other progressive peoples of modern times, is partly the result of original thinking but largely the result of developing and adapting knowledge obtained elsewhere. In some branches there appears a tendency to accept the leadership of foreign teachers without critical investigation, thus repeating the experience of America with reference to German science and that in turn with reference to Greece and Arabia. G. W. S.

Tyndall's Experiments on Magne-Crystallic Action. SIR WILLIAM BRAGG. *Sci. Mo.*, **25**, 65–79 (July, 1927).—A detailed review of Tyndall's experiments on the nature of the effect of a magnet on different substances and the bearing they have on the explanation of diamagnetism and paramagnetism. The original paper needs to be read to be understood. Several drawings are included with the text. G. W. S.

Toxic Gas and the Boll Weevil. EDITORIAL. *Chem. Age*, **17**, 2 (July 2, 1927).—Thus far the engagement between Gen. Amos Fries, head of the U. S. A. Chemical Warfare Service, and the boll weevil has proved inconclusive. 150,000 boll weevils, collected from all over the country, were kept in cold storage and subjected to about 1000 different poisons. Sixty-two surpassed calcium arsenate in deadliness, twenty-two of which caused little or no injury to the cotton plant. Five of these, sodium and barium fluosilicates, barium fluoride, cryolite, and a specially prepared calcium arsenate

appear to offer commercial possibilities. "No substance was found which definitely attracted or repelled the boll weevil or irritated it sufficiently to make it fly." Attempts to make calcium arsenate more pleasing to the palate by the introduction of various oils proved unsuccessful. The most powerful irritants to man produced practically no irritation or excitement. Volatile toxic gases of concentrations much greater than the known poisonous effect had very little effect on the weevil, although it could be killed by longer exposure to lesser concentrations. D. C. L.

Presentation of the Medal of the American Institute of Chemists. *Science*, **65**, 555–64 (June 10, 1927).—The Medal of the American Institute of Chemists was presented on May 11, 1927, to Professor Lafayette B. Mendel, of Yale University, in recognition of his meritorious work in biochemistry and his broad influence as a teacher. Professor Graham Lusk of the faculty of the Cornell Medical College introduced the medalist with a survey of his life and work. Mendel's speech of acceptance on "Some Tendencies in the Promotion of Chemical Research" reviews the changes in the methods of scientific research and prophesies new improvements in the teaching of chemistry. H. F. J.

Isotopes of Calcium. E. K. PLYLER. *Science*, **65**, 578–9 (June 10, 1927).—By the use of polarized light Plyler has studied the selective reflections of several carbonates at about 6.5μ. In the case of calcite three small maxima were observed at 6.36μ, 6.54μ, and 6.62μ. The relative intensities of these bands indicate that the first is one-twentieth as intense as the second and the third one-fifth as intense as the second. These results show that it is likely that calcium is made up of isotopes of atomic weights of 39, 40, and 44 and that the ratio of these is that given for the intensities, the mean atomic weight being 40.07. H. F. J.

A Micro Blood Sugar Method and the Blood Sugars of Insects. R. BLUMENTHAL. *Science*, **65**, 617–9 (June 24, 1927).—Using a modification of the method of Folin and Wu so that 0.03 cc. of blood drawn from a single insect is sufficient for the quantitative determination of blood sugar, Blumenthal measured the blood sugar content of several species of grass hoppers and Japanese beetle larvae. Preliminary checks on known solutions indicate the method is accurate to within about 3 per cent. The data, although limited, suggest that taxinomically related species may have blood sugar quantitatively similar. H. F. J.

Biochemistry. R. KEITH CARMAN. *Sci. Prog.*, **22**, 11–8 (July, 1927).—Work is being done by Hill and Myerleof on the anaerobic breakdown of carbohydrate into lactic acid as the immediate source of muscle energy. This may be considered a fermentative process being without oxygen. The consumption of oxygen by the muscle depresses the lactic acid formation in a definite quantitative manner. The consumption of one molecule of oxygen by the muscle reduces the anaerobic lactic acid formation by one to two molecules. There is, therefore, a quantitative relation between the dual metabolic activities of respiration and fermentation. E. S. R.

The Meaning of Radioactivity for the Face of the Earth. OTTO HAHN. *Naturw. Monatsh. biol. chem. geograph. geol. Unterricht*, **24**, 65–76 (July, 1927).—The age of the solid earth's crust is estimated to be: (1) 1.5 to 570 million years from the helium content of the various rock strata, (2) about 1000 million from its lead content, (3) 470 million years from pleochroic halos.

The constant heat of the earth is due to the radium, thorium, and uranium content of the volcanic and sedimentary rocks. The former contains the greater amount. The concentration per gram of rock is approximately 10^{-12} grams for radium, 10^{-1} grams for uranium, and 10^{-1} grams for thorium. B. H. B.

The Students of Chemistry in the Prussian Technical High Schools and Universities. L. K. GOETZ. *Naturw. Monatsh. biol. chem. geograph. geol. Unterricht*, **24**, 109–115 (1927).—Statistical paper. B. H. B.

Individual Instruction in High School. CARL E. WHINNERY. *High-School Teacher*, **3**, 167–9 (May, 1927).—The author reports that the division of freshmen according to ability by intelligence tests made "impossible administrative problems" and had little support from his teachers except "those who had the better groups."

The failure of such classification led his school to a study of plans of individual instruction. One of his major aims, as an administrator, was the prevention of waste of time.

In solving the problem of eliminating this waste, the "indeterminate assignment" plan was used. This calls for a major part of the teacher's time devoted to conferences with the pupils. Something of the technic and administration of the plan is described. Some very helpful books which aided his teachers in their work with this type of instruction are named.

There are some objections such as: Good students under the old plan sometimes fail under this plan; poor students go so much more slowly when mastery is required; whatever social value the general recitation may have is somewhat lessened in the new way; bright lazy pupils don't like the method. There are compensating values which more than offset these questionable disadvantages. For instance, it was found that the students took quite a different attitude toward their work; greater thoroughness was attained; ability to get instruction from the printed page was noted, and assignments were completed with a need for less outside or home work. B. C. H.

Shooting Stars. GEO. W. GRAY. *American*, **103**, 26–7 (June, 1927).—The body of the essay is in the form of an interview with Doctor Harlow Shapley, director of Harvard College Observatory, and Doctor Willard J. Fisher of the same observatory. The latter is making a special study of meteors. There is much in the article of interest to those interested in the subject.

Those teaching chemistry will be interested in "the chemical make-up of meteors." These studies are of special interest to all who wonder, "Of what is the universe made? ....Are the stars of the same substance as the earth?....Meteors which fall to earth ....may be handled, broken into, ...submitted to chemical tests."

Thus far, we have not found any new elements in meteorites but we have found unique combinations. Meteoric iron has a different texture from manufactured iron, and it is always in alloy with nickel. Some meteoric material found in the Sahara Desert in 1924 was found to contain a new kind of meteoric iron. Three kinds of meteoric iron were known previous to this find. This Sahara meteor contributed the fourth. B. C. H.

Many Students Now Pay Their Way through College. EDITORIAL. *School*, **38**, 820 (July, 1927).—The Federal Bureau of Education finds that 39 per cent of the entire enrolment of the 408 colleges and universities in the U. S. last year were partially or wholly self-supporting. Their earnings totaled $25,500,000. 44 per cent of those in co-ed institutions earned their way, while in the men's colleges $1/3$ and in the women's colleges $1/6$ of the students earned part of their expenses. E. L. M.

Home Study of High-School Students. ANON. *School*, **38**, 740 (June 16, 1927).—In order to determine whether home-study time is apportioned to the best advantage in preparation of different subjects, a questionnaire was sent to 275 senior students of Western High School, Baltimore. The following summarizes answers received: history 80 min., Latin 58, stenography 57, mathematics 46, modern languages and chemistry each 45, English 42, biology 38. The average per pupil per subject is 53 minutes. E. L. M.

State Examinations in High-School Science. A Protest. W. F. HOYT. *Nebr. Educ. J.*, **7**, 307–8 (June, 1927).—The writer wishes to record his protest against the new type test for high-school science. The questions he considers a jumble of grains of truth mingled with a peck measure of chaff. In the examination criticized many problems were solved by the examiner and the pupil asked to select the correct answer. The writer maintains that guessing at the answer, without the slightest idea of the principles involved, results when such tests, especially true-false, are used. Grading by marking the right guesses and subtracting the wrong, he considers preposterous. Since physics and chemistry are based on particular terms, principles, laws, and problems, the writer believes the examination should cover this basis rather than making it a guessing game. E. L. M.

Principles Underlying the Curriculum. EDITORIAL. *School*, **38**, 786 (June 30, 1927).—Because of the fact that modern life is so complex and in order that modern education may enable the pupil to participate in life both when he is a child and when an adult, the curriculum should be developed on the basis of certain principles. The New York City Committee on revision of course of study has endeavored to give due weight to each of these principles so that the development of the pupil may be in harmony with his nature and the demands of life. The principles considered by the committee are: (1) The ethical principle; (2) Principle of health; (3) Sociological principle; (4) Principle of culture; (5) Principle of emotional, aesthetic, and volitional development; (6) Principle of coördination; (7) Principle of continuity and growth; (8) Principle of individual differences.

Each principle is discussed in the article and references to fuller discussion given. E. L. M.

Moral Character the Aim of Education. EDITORIAL. *School*, **38**, 787 (June 30, 1927).—Dr. O'Shea, in commenting on the New York City curriculum, laid especial stress on this aim of education. He desires, above all, to see in the pupils good taste, manners, noble ideals, consideration for others, good conduct, and all the attributes of

character. In conclusion he states: "Therefore we hope to strike a ringing ethical note in our work which will tell all teachers that, important as other phases of education are, the fundamental aim in education is the development of moral character."

E. L. M.

Henry Paul Talbot. JAMES F. NORRIS. *Tech. Rev.*, **29**, 480 (July, 1927).—On June 18, 1927, occurred the death of Dean Henry Paul Talbot of the Massachusetts Institute of Technology. In the *Technology Review* of July, Dr. James F. Norris, a confrère and fellow faculty member, writes of the late Dean:

"The death of Dean Henry Paul Talbot deprives the Institute of the services of one of its most cherished Alumni, one who devoted his life in a noteworthily unselfish way to the upbuilding of his Alma Mater. For forty years he gave the best of his brain and heart to the development of teaching and administration, to the advancement of the Massachusetts Institute of Technology as a great school of engineering and science.

"Dr. Talbot was graduated from the Institute in 1887 and received the degree of Doctor of Philosophy from the University of Leipsic in 1890. He returned to the Institute as an instructor and was rapidly promoted through the several grades and was finally appointed professor of analytical chemistry in 1898. He showed marked administrative ability and from 1895 was nominally in charge of the Department of Chemistry, although his official appointment to this post was not made until 1901. He served as Chairman of the Faculty from 1919 to 1921, as Chairman of the Administration Committee from 1920 to 1923, and as Dean of Students from 1921." S. W. H.

College Teachers. EDITORIAL. *Harvard Grad. Mag.*, **35**, (March, 1927).—A few months ago the American Council on Education made public the results of a study in college personnel work. This report covered many topics, one of them being the selection of college teachers. The methods used by fourteen outstanding institutions were investigated, with the conclusion that no one of them had a clear, unequivocal, grade policy in this regard. One may take issue with this conclusion, and may deny the right of any investigator to pass judgment on this matter in such general terms; but it may be worth noting that the selection of instructors is the only thing set down in this survey as a matter open to marked improvement in all the institutions studied. The implication is that colleges select their students with greater efficiency than they recruit their teachers.

Poor teaching is not always an indication that poor teachers are at work. Quite as often it results from overloading good teachers. No matter how alert and capable a young instructor may be when he starts, you can turn him into an uninspiring routiner by imposing an excessive burden of class-room work and administrative chores. He will then have no time to read, no time to write, no time for anything but the endless round of lectures, recitations, essay-reading, examinations, and committee meetings. He becomes part of a machine which is supposed to register so many turns per minute. His teaching gets mechanized, as a matter of course, and the students proceed in their own barbaric way to blame the man, not the system.

"Nine out of ten college teachers in the United States are asked to do too much. This is particularly true in the larger institutions where the teacher is expected—yes, virtually required—to make a reputation as a productive scholar. Much has been said and written about the underpayment of college teachers, but overwork is no less serious an evil than underpay. It is desirable that university authorities should explore the possibilities in the way of ameliorating this situation. The amount of education obtained by the students does not depend upon the number of courses offered or on the number of hours that teachers spend in the class-room. If that were the case, Oxford and Cambridge would make a poor showing, for the period of active instruction at these institutions covers only six or seven months of the year. During the rest of the time the undergraduate is on his own—and he seems to make good use of the opportunity to work in his own way. In the United States we have been prone to assume that the class-room or laboratory, with an instructor supervising it, is the only place in which education can be obtained—yet everywhere we hear it said that self-education is the only true education. The practice and the profession do not seem to jibe." S. W. H.

In the Wash. ANON. *Tech. Rev.*, **29**, 280 (March, 1927).—Largely in form of control of heat and hydrogen ions, science has come now to the aid of the laundry bundle. The longevity of linens is prolonged; the expectation of life for a collar is augmented. Research started more than two years ago under the direction of Robert P. Russell, Assistant Director of the Research Laboratory of Applied Chemistry, has resulted in several discoveries of fundamental importance whereby the laundries of the country, long without technical control of their chemical processes, are now happily able to accomplish three much needed results: to increase the efficiency of the operation with con-

sequent saving of cost; to increase the life of the average garment; to better the quality of laundry work.

So obvious a matter as that of temperature control during various washing processes has been in large measure responsible for these three results. Temperatures of water in a laundry washing were formerly begun in the first stage at about seventy degrees. Through various stages they increased until at the bleaching process they were well above 150 degrees. Professor Russell and Henry O. Forrest, a divisional director of the laboratory, following intensive study, proved conclusively that if the temperature in the early stages were somewhat increased, the highest temperature might be reduced from over 150 degrees to about 120 degrees. It is this fact that has resulted in a possible saving in laundry operation of about thirty per cent of the total fuel used, sometimes doubling the life of a sheet or collar and causing less agony among the housewives of the nation.

It was not only applied chemistry but psychology which the Research Laboratory brought to bear upon its problem. One man may wear a collar three times as long as another, even though the two collars might be identical at the start and be washed under identical conditions. The nervous system of the wearer has much to do with the untimely end of the collar. Formerly its average life was six months. Under new methods it may be nine months or more. Sheets likewise may last under new conditions from one to two years longer than before. Actual wear, it has been proved, is more of a factor in deterioration than is laundering.

Twenty-three laundries coöperated in placing their problems in the hands of the Research Laboratory. The work included not only laboratory research, but study of actual laundry conditions and inspection of plants to see that recommendations made on the basis of laboratory work were properly carried out in the plant. S. W. H.

Innovation in Method of Instruction at Harvard. EDITORIAL. *Harvard Grad. Mag.*, **35**, 653 (June, 1927).—One change at Harvard has been more discussed than any other made during the present term, and is, perhaps, the most drastic innovation in the methods of instruction since the beginning of the system of general examinations. This is the adoption of a scheme by which hereafter in most Harvard courses all formal instruction in the first half-year will stop at the beginning of December vacation, and in the second half-year, about May 1st. Tutoring work will be suspended, too, during the weeks in which instruction in courses is discontinued. The result of the plan will be that two and a half weeks in January and three and a half weeks in May, during which classes now meet regularly, will hereafter be periods in which the suspension of most lectures, recitations, tutorial meetings, and other formal "college engagements," will leave students relatively free to use their time in other ways. These periods are now being referred to as "reading periods," and they are in no sense designed to be vacations. In each course reading will be assigned to be done, during the time after class meetings, independently. The new scheme will not apply to elementary courses, which courses in each department will be conducted throughout each half-year as at present, and certain other courses in each department will no doubt have to be exempted from the operation of the new system on account of special demands made by their subjects and methods. S. W. H.

Dyes and Their Application: Recent Technical Progress. L. J. HOOLEY. *Chem. Age*, **16**, 47 (June 11, 1927).—This article is a brief resumé of the theories of dyeing. Factors affecting dyeing are: degree of dispersion or ionization, properties and condition of the fiber, and the possibilities of electric charges on the surface, manner of contact, state of penetration, adsorption, coagulation, precipitation of colloidal particles, or compound formation. Most dyes from dispersions intermediate between solutions and colloids and their dyeing properties may be due chiefly to degree of dispersion rather than chemical constitution although the latter may be the factor determining degree of dispersion. "Only a few basic colors are sufficiently aggregated to show particles as large as those of the direct colors and it may be because they are so small that they will not dye cotton without a mordant." In many cases dyeing wool with acid dyes consists of salt formation between the wool acting as a base and the dye as an acid. Numerous experiments favor the adsorption and electrical theories. D. C. L.

Chemical Formulas of Mineral Compounds. L. W. TIBYRIÇA. *Nature*, **119**, 815–6 (June 4, 1927).—The author considers that certain theoretical considerations, not given in the note, require that the chemical formulas of all true mineral species composed of any of the first twenty-one elements of the periodic system should obey the simple equation $M = 2a + 8n$ where M is the molecular number (that is the total atomic number of the compound), a the number of atoms excluding hydrogen, and n an interger. This formula is critically discussed by J. W. E. H. K. M.

Local Activities and Opportunities

ROCHESTER SECTION, A. C. S.

Tentative Topics—1927–1928 Program

October 3, 1927, Dr. J. Kendall, New York University, New York, "Some Separations Old and New, by the Ionic Migration Method."

October 17, 1927, Dr. C. Noller, Eastman Kodak Company, Rochester.

November 7, 1927, Dr. A. S. Burdick, Abbott Laboratories, Chicago, "Medicinals and Pharmaceuticals."

November 21, 1927, Mr. E. G. Miner, Pfaudler Company, Rochester.

December 5, 1927, Dr. S. W. Parr, University of Illinois, Urbana, "Fuels."

December 19, 1927, Dr. Ethel Luce, University of Rochester Medical School, "Vitamins and Ultra-Violet Light."

January 9, 1927, Dr. G. T. Moore, Missouri Botanical Gardens, St. Louis, "Smoke."

January 23, 1927, Dr. K. C. D. Hickman, Eastman Kodak Company.

February 6, 1927, Dr. Saul Dushman, General Electric Company, "Band Spectra and Molecular Structure."

February 20, 1927, Dr. G. W. Corner, University of Rochester Medical School, "The Discovery of the Ovum."

March 5, 1927, Dr. A. D. Hirschfelder, University of Minnesota, Minneapolis, "Pharmacology."

March 19, 1927, Dr. S. E. Sheppard, Eastman Kodak Company, Rochester.

April 2, 1927, Dr. O. Maass, McGill University, Montreal, Canada.

April 16, 1927, Mr. I. N. Hultman, Eastman Kodak Company, Rochester, "Wood Distillation."

May 7, 1927, Some speaker on "Anti-Knock Fuels."

May 21, 1927, Dr. H. C. Parker, Leeds & Northrup, Philadelphia, "Electrometric Measurements."

Carnegie Institute of Technology. A new course in heat engineering planned to meet an increasing demand for engineers trained in conservation of fuel is to be offered at the Carnegie Institute of Technology next year. The new course will be offered as an option in the Department of Mechanical Engineering and will be conducted under the direction of Professor W. Trinks, head of the department, and a national authority on furnace, combustion, and fuel technology problems.

"With both the demand for fuel and the cost of fuel rising, and likely to do so at an accelerated pace in the future," the announcement points out, "there is an increasing demand for engineers who can conserve fuel. Such men readily find a place in all of those industries in which a great deal of fuel is used, such as steel plants, power plants, railroads, glass works, coke works, large chemical plants, etc.

"Only recently has it been realized that the fuel saving effected by such men is many times greater than the cost of their employment. As a result there is a demand for engineers who are variously termed combustion engineers, heat engineers, or fuel engineers. Their work consists in saving fuel, whether it be in the power plant or in the industrial furnace; in the application of waste heat to the heating of buildings; in better insulation of furnaces and ovens; or, finally, in the selection of cheaper fuel.

"The training requirements for such engineers are not properly fulfilled by the usual conventional courses pursued by the mechanical engineer, metallurgist, chemist, or physicist. The engineer who

is to qualify as a heat engineer must have some of the knowledge and training of each of these types of engineers and scientists, but on the other hand he need not have all of the knowledge that is commonly supposed to be acquired by any one of them. In practice, heat engineers have been recruited from chemists, physicists, mechanical engineers, or metallurgical engineers; the selection has usually been accidental, depending upon the type of man who is handy and who is available for the work.

"The heat engineering option in the Department of Mechanical Engineering is intended and designed to fill the gap. From it are omitted all of those purely mechanical subjects with which the heat engineer seldom has to deal, and they are replaced by subjects in physics and chemistry, particularly the latter. Thus the student, if he decides upon this field of endeavor early enough in his course, may elect the heat engineering option and complete his training in four years instead of spending an additional year in post graduate work."

In connection with the new courses the announcement also points out, a combustion tunnel has been installed in one of the laboratories for instructional and experimental purposes. It is said to be the only tunnel of its kind in any college or university in this country.

Oil Result of Brine-Pickled Animals, Thinks N. Y. Expert. The gas that makes the car go and the oil that lubricates its pistons were made drop by drop by tiny animals that lived in salt lakes millions of years ago. This is the theory advanced by John Rogers in an article which will be published in an early issue of *Science*. Many geologists believe that oil was made by such animals living in the sea. Mr. Rogers agrees with them so far as a salt-water environment is concerned, but believes that it existed in the form of salt-water lakes, like the Great Salt Lake of Utah and the Caspian Sea of the Old World, rather than in open seas. He argues as follows:

"Oil fields are quite frequently found contiguous to salt deposits, and the water which succeeds the oil in most wells is salt water.

"In some brine lakes, such as Great Salt Lake, Utah, there is a great deal of marine life, but of very small size. In Great Salt Lake there is an abundance of very small shrimp or crayfish, and in certain of the marshes on the lake shores these small creatures seem to die in large numbers, so much so that the marshes in places give off an almost unbearable odor, much similar to the smell of drying cod fish.

"The natural presumption is that the bodies of these small creatures do not decompose in the ordinary way but become pickled in the brine and are more or less permanently preserved.

"Where conditions have been favorable and mud beds formed, having the preserved remains of this small marine life imbedded in them, this mud might very readily have been changed into beds of shale carrying a large percentage of oil. Petroleum may possibly be a distillation from such shale, and being fluid may have moved about over a considerable area.

"Mud banks would normally form at the mouths of rivers flowing into the brine lakes and the rivers would be continuously carrying into the lakes large quantities of organic matter, which would be acted on by the brine and deposited with the mud.

"Some forms of vegetable life seem to grow freely in water containing a very high percentage of salt. Such vegetable matter probably would not decompose in the ordinary way. It seems quite possible that the difference in the composition of mineral oils from different locations may be due to the different proportion of animal to vegetable matter in the original deposition."—*Science Service*

Recent Books

New Conceptions in Colloidal Chemistry. HERBERT FREUNDLICH, PH.D., Professor at the Kaiser Wilhelm Institute for Physical Chemistry, Berlin. E. P. Dutton and Company, New York, 1927. With 47 diagrams and 20 tables. vii + 147 pages. 12.5 × 18.5 cm. $2.00.

This book contains the subject-matter of a series of lectures given by the author in the University of Minnesota during the summer of 1925. The title is indicative of the nature of the contents; its purpose is set forth in the preface as follows: "Science consists in approximations. We first form a more or less rough and crude picture of the phenomena we are dealing with, and then draw it more exactly and with greater precision, as our knowledge grows. This development may be observed very clearly in capillary and colloidal chemistry. The general conceptions of adsorption, the electrical potential of surfaces, the state of aggregation and shape of particles, which conceptions were sufficient some years ago, had to be worked out in greater detail in order to account for the manifold new experimental results." The author has succeeded in correlating the recent experimental data concerning these topics, and has brought the generalizations together in a logical and pleasing manner. Other topics which have received similar treatment are: the rate of coagulation; the stability of hydrophilic sols; the extent and change of surface in colloidal systems; and photo-dichroism and similar phenomena.

The book is well written and the theoretical treatment has been developed with commendable fairness. Research workers and advanced students in colloid chemistry will find the book stimulating as well as instructive. It can be read with profit by any one who has a fair knowledge of the literature of colloid chemistry, though from the standpoint of general information it can in no sense replace the other recent books by this author.

The reviewer feels that this book could well serve as the beginning of a series of books of the same general title, preferably by the same author, which would appear periodically, say, at about three-year intervals.

F. E. BARTELL

Lehrbuch der Enzyme. CARL OPPENHEIMER, with the collaboration of Richard Kuhn. Georg Thieme, Leipzig, 1927. ix + 660 pp. 17 × 25 cm. 18 figures. Unbound, 33 M.; bound, 36 M.

This textbook represents an abridged form of the fifth edition of Oppenheimer's "Die Fermente and ihre Wirkungen." The same outline or arrangement of material was used in both instances and many sentences or paragraphs have been carried over from the larger work into the Lehrbuch. Since the latter appeared two years later than the first volume of Die Fermente, it follows that certain changes have been made in order to bring the Lehrbuch up to date. Because of the less extended treatment accorded each section in the Lehrbuch, the authors have been more didactic than was the case in organizing Die Fermente. This may be of advantage to the student, since he is not left in doubt concerning the author's opinions and conclusions.

Oppenheimer has treated this complex subject under two major divisions, designated as I General, and II Special. In the first part the enzymes are considered more or less collectively. The descriptive

chemistry of enzymes, influence of various factors upon enzyme action, physical chemistry, and kinetics, occurrence and formation of enzymes, and the significance of enzymes in vital economy are discussed in some detail. The reviewer has been very favorably impressed by the treatment accorded the physical chemistry and kinetics of enzyme phenomena.

The second division includes the detailed consideration of the several individual enzymes, which have been subdivided in turn into the two groups, (*a*) the hydrolases, and (*b*) the desmolases. Origin, preparation, chemical changes accelerated by, and activators of the enzymes are discussed in each instance.

As a reference work, its most outstanding deficiency is the scarcity of literature citations, comparatively few of these appearing anywhere in the volume. As a textbook, this volume should prove very useful to the student.

C. H. BAILEY

Biochemical Laboratory Methods for Students of the Biological Sciences. CLARENCE AUSTIN MORROW, PH.D., late Assistant Professor of Agricultural Biochemistry, University of Minnesota. John Wiley and Sons, Inc., New York City, 1927. xvii + 350 pp. 15.2 × 22.8 cm. $3.75.

This book has been designed especially as a laboratory text for those taking a lecture course in phytochemistry, but according to the author "the needs of those students whose life work will lie in other branches of the biological sciences have been kept in view at all times."

Practically 102 pages of this text have to do with experiments involving the study of the physical chemistry of plant protoplasm, and these experiments are well adapted to meet the needs of a student taking a course in phytochemistry in which the fundamentals of physical chemistry and their relation to biochemical phenomena are stressed, and where the student has had no previous training in physical chemistry.

Sixty-four pages are devoted to the laboratory study of proteins and the experiments, listed among others, involve the isolation of proteins, the isolation and synthesis of amino acids, color tests of both proteins and free amino acids and the determination of certain of their reactive groups.

Sixty-one pages are devoted to the laboratory study of carbohydrates, 16 pages to lipins, 31 pages to enzymes and 19 pages to plant pigments. In practically all the experiments plant materials are required, but these are used in studies of compounds of interest to both animal and plant biochemists. In certain instances, a study of materials peculiar to the plant alone have not been considered.

The nature, number and details of the experiments leave little to be desired. A great many of these experiments are quantitative in nature; a number of which, including the determinations of fat constants, are ordinarily taken up in the study of the chemistry of foods. However, most of the experiments are of a qualitative rather than of a quantitative nature, which is probably more desirable.

The reviewer is of the firm opinion that this text, with extremely few modifications, is especially well adapted to meet the needs of those who are studying phytochemistry, and as a reference book on qualitative and quantitative methods for the study of the main organic compounds found in both plant and animal organisms, it is unsurpassed. On the whole, Dr. Morrow's book is carefully written and is a real contribution to the study of biological science.

E. HALEY

The Romance of Chemistry. WILLIAM FOSTER, PH.D., Professor of Chemistry, Princeton University. The Century Co., New York City. First Edition, 1927. xvi + 456 pp. 14 × 21 cm. $3.00.

In 1925 Professor William Foster

wrote his "Elements of Chemistry," intended for the beginning student of chemistry, and in which he illustrated the scientific text by some examples of their applications in daily life, thus stimulating the interest of the beginner and permitting him to better visualize the subject.

In the present book, "Romance of Chemistry," he reverses the relative extent of description of chemical science and its practical applications. The book is intended less as a guide for beginning students in chemistry than to open the eyes of the general public to the tremendous importance the applications of chemistry have acquired in every branch of our modern life.

The subject is presented so that the average reader unacquainted with chemistry may understand it.

Quite naturally the lay reader of inquisitive mind may want more information involving some theoretical explanations. Such additional information is disseminated throughout the text in special chapters and paragraphs, but in such a manner that their reading is not indispensable to follow the descriptive part of the subject, which is presented in such clear and simple language that anybody of average education can understand it.

L. H. BAEKELAND

General Chemistry. HAMILTON P. CADY, PH.D., Professor of Chemistry, University of Kansas. Second Edition. McGraw-Hill Book Co., Inc., New York, 1926. xviii + 540 pp. 73 fig. 14 × 20.3 cm. $3.25.

Designed for the introductory course in college chemistry, this text is clearly the product of an experienced and capable teacher. The author follows the plan of treating the non-metals before the metals. Oxygen, Hydrogen, Water, the Laws of Gases and Mobile Equilibrium precede Symbols, Equations and the Atomic Theory. Chlorine is next presented as a typical non-metal and as an introduction to Acids, Bases, Neutralization and the Ionic Theory. The remaining common non-metals are treated in the reverse order of their appearance in the periodic table.

Following the non-metals, a chapter is devoted to a general introduction to the chemistry of the metals, which includes their periodic classification, atomic structure and distinguishing characteristics. The metals are then studied by groups and subgroups, the last chapter being devoted to radio-activity.

The author is conservative in his employment of the electronic theory. The statement on page 190 that "oxidation and reduction consist merely in a transfer of + charges" will probably not satisfy those who prefer to visualize the transfer of electrons. However, his treatment of oxidation and reduction reactions is very fine. Group relationships and subgroup characteristics are especially emphasized. He has included many tables of properties and has paid particular attention to analytical reactions. The text is therefore suitable for use in connection with a laboratory manual of qualitative analysis. Important industrial processes are discussed from the standpoint of the principles involved.

The book is strongly bound; the type is large and the illustrations, figures, and charts are clear and attractive. The text is well indexed and contains descriptions of such a large number of substances as to make it a desirable reference.

R. A. BAKER

List of References on Vocational Guidance. (Prepared in the Library Division, John D. Wolcott, Chief.) Bureau of Education, Washington, D. C., May, 1927. Library Leaflet No. 33. 22 pp. 15 × 23 cm. (Free.)

References listed under the following headings: General References; Elementary Schools; High Schools; Junior High Schools; Colleges and Universities, Including Teachers Colleges; School Counselors and Personnel Management; Vocational Psychology; Occupations; Guidance of Negroes; Guidance in

Continuation Work; Vocational Tests; Foreign Countries; Bibliographies; Periodicals Indexed.

Progress of Rural Education 1925 and 1926. KATHARINE M. COOK. Bureau of Education. Bulletin, 1927. No. 15. 46 pp. 15 × 23 cm. $0.10.

Advance sheets from the Biennial Survey of Education in the United States, 1924–1926.

Elementary Physical Chemistry. HUGH S. TAYLOR, D.Sc. (Liverpool.) Professor of Chemistry, Princeton University. First edition. D. Van Nostrand Company, New York, 1927. ix + 531 pp. 108 figures. 10.3 × 17.3 cm. $3.75 net.

As stated in the preface, "the present volume attempts the presentation of material suitable for an introductory course in modern physical chemistry. It is adapted from the two-volume 'Treatise of Physical Chemistry,' which appeared under the author's editorship some three years ago." The author notes the prevailing custom of including much physical chemistry in our courses in general chemistry, and believes that "physical chemistry ought to reap the advantages of that development and is therefore offered the possibility of substituting for the descriptive, qualitative course a more rigorous and, therefore, more mathematical discipline." "Another more compelling reason for this decision, however, is the modern trend in physical chemistry. Any teacher who would advise his students that he can attain to an understanding of the science as now developing without the mathematical knowledge required in the present volume is, in the opinion of the author, doing an ill service to his pupils."

The treatment of the subject matter is very logical and forceful, and to the expert in physical chemistry will, no doubt, be perfectly clear. There is, however, some question as to the appropriateness of the word "elementary" in the title. Unless a student has had a great deal of training, not alone in mathematics, but in its application to chemical problems, he will not be able to follow many passages at all. It may be argued, of course, that this is where the teacher comes in, but it is the opinion of the reviewer that any text should be self-explanatory. The mathematical treatment is not only good, but absolutely necessary, in the development of many topics, but in an "elementary" course the application of the mathematics will have to be explained. A ladder is the best means of getting into a tall tree, but the end of the ladder needs to be on the ground. The textbook in physical chemistry has yet to be written in which the mathematical treatment begins where the student's training left off, or better, where the student's ability ends. Most sophomore students have had algebra, geometry, trigonometry, and some calculus, but these same students have to be taught how to use negative and fractional exponents, and when to see the application of a quadratic equation, if not how to solve one. And when, in solving a quadratic, they get two values, they do not see *until they are told* that one value is probably impossible. Will the average student even understand, *without explanation*, that we can plot $\sqrt{\nu/R}$ in place of $\sqrt{1/\lambda}$ (pp. 33, 34) without doing violence to the truth? Why not tell him so? Let us use all the mathematics necessary, but let us begin "on the ground." If we do not, the mathematical explanations are absolutely unreadable to the average student; and let us not forget that an "elementary" physical chemistry has to be written for use of the "average student," not for the teacher.

In spite of what has been said above, the reviewer believes that much—indeed most—of the present volume is beautifully done. The chapter on "The Atomic Concept of Matter" is a fine thing, and the chapters on "The States of Aggregation" and "Equilibrium" are equally well done. The student, with proper

previous training, should be able to get most of this material. The chapter on "Colloid Chemistry" is too much condensed to help the student very much. A great deal of this subject is still in the qualitative stage, and to treat it in mathematical terms *only* is like explaining a painting in terms of spectral analysis.

W. H. CHAPIN

Contemporary Developments in Chemistry. (A series of lectures.) Columbia University Press, New York City, 1927. 461 pp. 15 × 23 cm. $11.00.

Those who were unable to attend the truly unique series of lectures on Contemporary Developments in Chemistry offered at the 1926 summer session of Columbia University will welcome the news that these lectures have been collected and are now available to the public in one volume. It is to be hoped that the price of the volume—necessarily high to cover the expense of a small edition—will not too greatly dampen the general enthusiasm.

A reviewer would need unlimited space and colossal self-confidence to attempt critical comment on each lecture in turn. The reader's interests will be best served by appending a list of subjects and lecturers with the amount of space employed by each. It is evident that some subjects have been treated with much greater detail and thoroughness than others. This of course is one of the inevitable characteristics of such a collection and is not to be taken as a specific criticism of the present volume.

The book is printed upon paper of excellent quality and is well bound. There is a general list of contents and each lecture has its own title-page and table of contents and is separately paged.

The list of contents follows:

Synthetic Organic Chemistry in the Study of Odorous Compounds, Marston T. Bogert, 28 pp.

Chemical Reactivity, James F. Norris, 13 pp.

Chemical Relationships of Sugars, Optically Active Amino Acids, Hydroxy Acids and Halogen Acids, Phoebus A. Levene, 26 pp.,

Reversible Oxidation-Reduction Reactions in Organic Systems, W. Mansfield Clark, 20 pp.

Crystal Structure in Its Relation to Chemical Problems, Ralph W. G. Wyckoff, 19 pp.

Catalysis and the Mechanism of Chemical Reactions, Hugh S. Taylor, 16 pp.

Carbohydrates, Sir James Colquhoun Irvine, 28 pp.

Oxidative Catalysis in the Body, Edward C. Kendall, 20 pp.

Immunology as a Branch of Chemistry, H. Gideon Wells, 17 pp.

Rare Gases of the Atmosphere, Richard B. Moore, 21 pp.

Synthetic Organic Chemistry, E. Emmett Reid, 8 pp.

Permeability and Electric Phenomena in Membranes, Leonor Michaelis, 14 pp.

Radicals as Chemical Individuals, Charles A. Kraus, 16 pp.

The Influence of Pressure upon Chemical Transformations, Ernst Cohen, 12 pp.

A Development in the Chemistry of Sanitation, John Arthur Wilson, 24 pp.

The Direct Measurement of Osmotic Pressure, J. C. W. Frazer, 20 pp.

Chemistry of Bacteria, Treat B. Johnson, 14 pp.

Contact Catalysis, Wilder D. Bancroft, 15 pp.

Water-Soluble Vitamins, Elmer V. McCollum, 10 pp.

Quantitative Research in the Chemistry of Nutrition, Henry C. Sherman, 19 pp.

Theory of Velocity of Ionic Reactions, J. N. Bronsted, 29 pp.

Physico-Chemical Principles in Electro-Metallurgical Research, Colin G. Fink, 17 pp.

Reactions in Liquid Ammonia, E. C. Franklin, 22 pp.

Agricultural Chemistry, Charles A. Browne, 17 pp.

Completing the Periodic Table, B. S. Hopkins, 16 pp.

O. REINMUTH

"A Few Moments with the Business Manager"

BOOK SERVICE

So many of our readers have written us relative to how and where certain reference or textbooks may be secured, we have made arrangements with the nation's leading publishing companies to secure for our readers ANY BOOK—text, reference, or otherwise—in ANY NUMBERS at the usual list prices.

Order your book or books through our office. Prompt and satisfactory service will be guaranteed. Tell us the book desired and how many copies and we shall see that they are promptly delivered to you. Let us supply the textbooks for your classes. You will get prompt service and will materially aid the JOURNAL OF CHEMICAL EDUCATION. Let us work together. No money need accompany the order.

JOURNAL OF CHEMICAL EDUCATION
343 State St., Rochester, N. Y.

Gentlemen:

Please order.....copies of

.....

.....

Delivery should reach me not later than.. .....,
I shall pay for the above within ten days after receipt of bill from your office.

Name.....

Street.....

City.....State .....

Magazine Service

On this page last month, were printed special rates for thirty of the country's leading magazines. These bargains are listed on pages 17 and 18 of this issue.

How much better it is to have your favorite magazines mailed directly to you each month. You do not miss a single issue. It is at home when you want something to read, and then it is so much cheaper to be a regular subscriber.

These various magazines are telling their agents and subscribers about our Journal so please help us reciprocate by telling your friends about these special offers and by taking advantage of them yourself.

PLEASE TURN TO PAGES 17-18